Environmental Assessment of the Alaskan Continental Shelf

Final Reports of Principal Investigators

Volume 20 **December 1983**

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Oceanography and Marine Services
Ocean Assessments Division

U.S. DEPARTMENT OF THE INTERIOR
Minerals Management Service

MARINE MAMMALS OF LOWER COOK INLET AND THE POTENTIAL FOR IMPACT FROM OUTER CONTINENTAL SHELF OIL AND GAS EXPLORATION, DEVELOPMENT, AND TRANSPORT

by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 243

1979

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INTRODUCTION

Petroleum exploration, production and transportation in marine waters have the potential for extensive environmental impacts. Major oil and gas development has taken place in upper Cook Inlet as a result of lease sales held by the State of Alaska between 1959 and 1974. There are five oil and three gas fields with 14 offshore platforms and a submarine pipeline network which carries the majority of the oil to the Drift River Terminal on the west side of the Inlet. Approximately 0.2 million hectares of lower Cook Inlet were leased by the Federal government in 1977. It is expected that 32 exploratory wells and 71 production wells will be drilled and three platforms required for production. Up to 442 kilometers of onshore and submarine pipeline will be needed depending on the location of the oil terminals and treatment facilities. Warren (1978) provides a complete scenario of development for the area. Future lease sales may include Shelikof Strait.

Studies of the biological, physical and chemical properties of the area are being conducted by the National Oceanic and Atmospheric Administration Outer Continental Shelf Environmental Assessment Program to provide the data necessary for managing petroleum development with a minimum of environmental degredation. The biological research should include studies of all trophic levels in order to identify sensitive organisms and to determine the effects of oil development on the ecosystem.

Marine mammals are high trophic level consumers and may be directly and severely affected by external contamination or ingestion of oil or through disturbance associated with petroleum development. Indirect effects include mortality or decreased vitality due to ingestion of compounds passed along the food chain and a decrease in the food supply due to oil caused mortality of prey items, and destruction of habitat in the form of oiling beaches making them unsuitable as hauling areas.

The economic importance, highly visible nature and aesthetic appeal of marine mammals are additional reasons for consideration.

Objectives

The objectives of this report are:

1. review: (a) all available data on marine mammals in Cook Inlet;

   (b) all pertinent information on the physical, chemical and biological properties of Cook Inlet and

   (c) the known oil operations, probable development scenarios and the fate of oil in the marine environment.

2. synthesize the data into a comprehensive discussion on marine mammal use of Lower Cook Inlet.

3. determine the potential for impact by oil and gas exploration, production and transportation on marine mammals.

Area of Consideration

The study area is located in southcentral Alaska and includes the waters and adjacent shores of Cook Inlet from the Forelands to Kennedy Entrance (Fig. 1). Shelikof Strait, which receives most of the waters leaving Cook Inlet, will also be included for consideration.

The area includes Cook Inlet, a tidal estuary, which flows into the Gulf of Alaska, is approximately 200 kilometers long and ranges in width of 16 kilometers at the Forelands in the northeast to 120 kilometers at the mouth in the southwest.

The climate of Cook Inlet is a transition zone between the Alaskan interior with its cold winters, warm summers, low precipitation and moderate winds and the maritime zone with cool summers, mild winters, high precipitation and frequent storms. Mean precipitation over the entire Cook Inlet is 53 cm per year (Evans et al. 1972). Northeast winds prevail in the winter while summer winds tend to be from the southwest. An extensive climatic description of Cook Inlet can be found in Evans et al. (1972) and Selkregg (1974).

The circulation of water in Cook Inlet is influenced by the seasonally variable fresh water runoff, the large tidal range of up to 6 meters (Trasky et al. 1977) and wind patterns. In general, water from the Gulf of Alaska enters Cook Inlet through Kennedy Entrance. This intruding water is diverted past Kachemak Bay and moves northward along the eastern

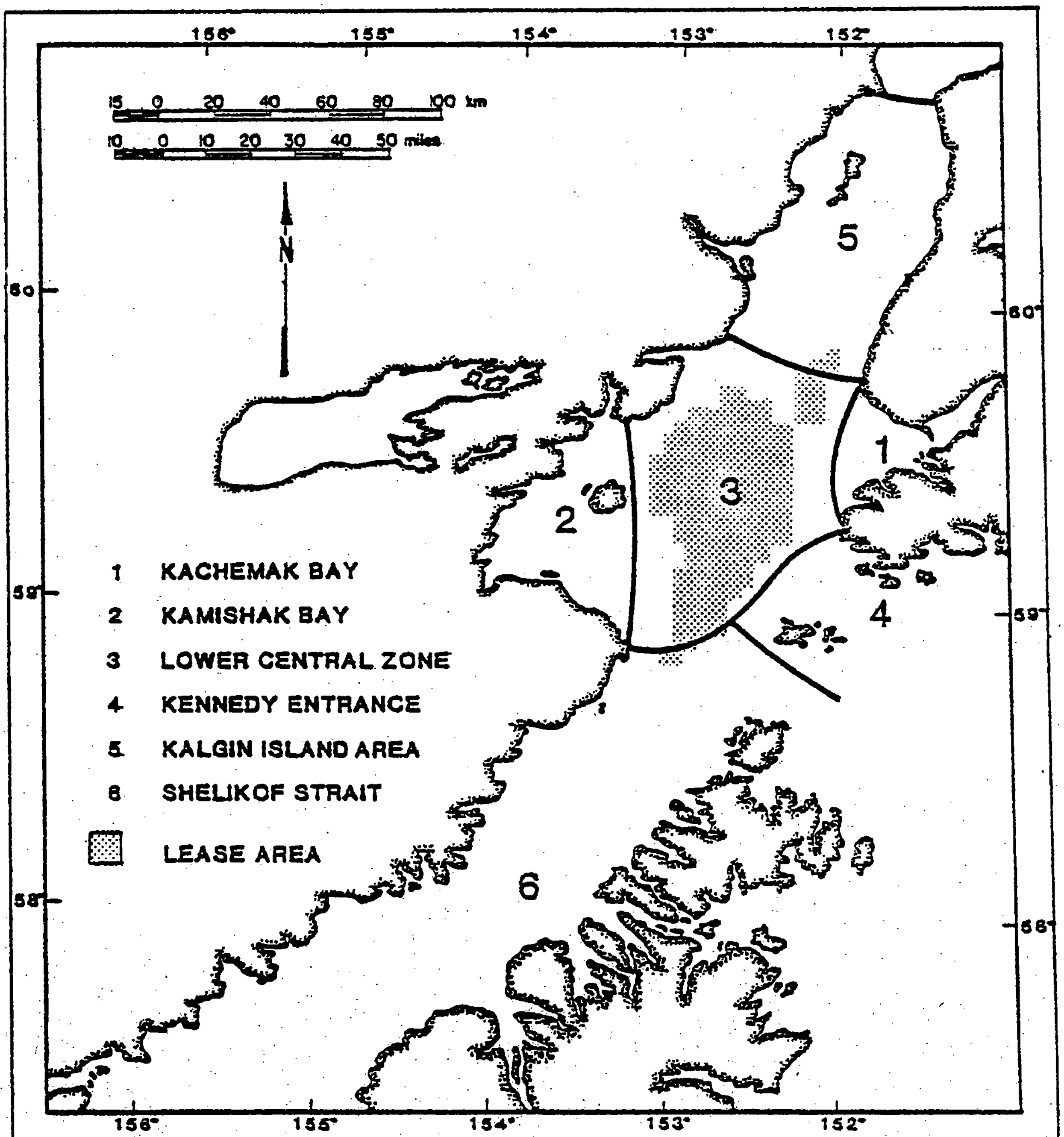

FIGURE 1. AREA OF CONSIDERATION FOR LOWER COOK INLET AND SHELIKOF STRAIT.

shore of Cook Inlet where a portion diverges sharply to the west at Anchor Point while the remaining northward flow extends past the Forelands. The water flowing westward from Anchor Point meets a southward flow of turbid, low salinity water from the upper inlet. This water flows south past Kalgin Island, through Kamishak Bay and into Shelikof Strait. The complexity of the circulation patterns is dealt with in detail by Burbank (1977) and ADF&G (1978a).

The study area can be broken down into six general zones: Kachemak Bay, Kamishak Bay, Lower Central Zone, Kennedy Entrance, the Kalgin Island area and Shelikof Strait (Fig. 1). An extensive background description of the area can be found in Sears and Zimmerman (1977), Science Applications (1977), Trasky et al. (1977) and ADF&G (1978a). The following is a short summary of each zone:

Kachemak Bay is located on the east side of Lower Cook Inlet and is characterized by depths to 165 meters and a diverse and highly productive fauna. The bay has an inner and outer region partially divided by Homer Spit, the outer region being relatively ice free in winter, whereas ice is commonly found at the head of the bay. The north coastline is smooth, with gradual slopes and beaches consisting largely of mud flats. The southern shore is irregular, with gradual slopes and beaches composed of intermittent stretches of gravel, sand and bedrock.

Kamishak Bay, located on the western side of Cook Inlet is relatively shallow, with depths to 56 meters. There appears to be less diversity in the fauna as compared to Kachemak Bay, although the region is still highly productive. The circulation pattern tends to carry sediments into the bay, thus increasing turbidity. Winter ice, which is formed in upper Cook Inlet, also tends to drift down the western side of the Inlet and accumulate in the bay. The coastline is indented with numerous small bays and coves which usually contain extensive mud flats. The remaining coastline is a mixture of gradually sloping sand, gravel and bedrock beaches. Augustine Island, found within Kamishak Bay, is a volcano with sand and gravel beaches.

The Lower Central Zone is located between Kamishak and Kachemak Bays. It is relatively deep, with vigorous tidal circulation, although the middle portion of this zone tends to be sluggish. Again, this region is highly productive.

Kennedy Entrance is located between the Chugach Islands, off the southern tip of the Kenai Peninsula and the Barren Islands. It is the main pathway for tidal exchange between Cook Inlet and the Gulf of Alaska. The entrance is narrow and deep (up to 128 meters), with extremely swift currents. The Chugach and Barren Islands are characterized by steeply sloping shorelines with narrow bedrock beaches.

The Kalgin Island area extends south from the Forelands to the Lower Central Zone and is a region of high turbidity due to mixing with the sediment laden waters from upper Cook Inlet. Winter ice from upper Cook Inlet is carried by currents and wind into this area. Although primary productivity tends to be low due to the turbidity and ice, the area is still an important fishing ground for salmon (ADF&G 1978a). This region, including Kalgin Island, has a relatively smooth coastline with gently sloping mud, sand and gravel beaches. The shoreline of Tuxedni Bay, the only major indentation, consists of an almost entirely uninterupted mud beach.

Shelikof Strait, an area characterized by high winds and heavy seas is located between Kodiak Island and the Alaska Peninsula. Most of the water from Cook Inlet tends to flow through Shelikof Striat along the Alaska Peninsula shore. The coastline is very irregular, with small bays, coves and lagoons found throughout the area. Considerable variation exists in the slope and composition of the beaches.

MARINE MAMMALS OF COOK INLET AND SHELIKOF STRAIT

The following discussion summarizes the life histories of the more important marine mammal species in the study area; these include sea otters (*Enhydra lutris*), Steller sea lions (*Eumetopias jubatus*), harbor seals (*Phoca vitulina*) and belukha whales (*Delphinapterus leucas*). The limited data available on humpback (*Megaptera novaeangliae*), gray (*Eschrichtius robustus*), Minke (*Balaenoptera acutorostrata*) and killer (*Orcinus orca*) whales and Dall (*Phocoenoides dalli*) and harbor (*Phocoena phocoena*) porpoises are also discussed. A list of all marine mammals likely to occur in lower Cook Inlet and Shelikof Strait appears in Table 1.

Table 1. Marine mammals species likely to occur in lower Cook Inlet and Shelikof Strait (from Calkins et al. 1975).

SPECIES	SIGHTINGS	USUALLY SIGHTED WITH 50fm CURVE	USUALLY SIGHTED OUTSIDE 50fm CURVE
Sea otter (*Enhydra lutris*)	C	X	
Steller sea lion (*Eumetopias jubatus*)	C	X	X
Northern fur seal (*Callorhinus ursinus*)	F	X	X
Harbor seal (*Phoca vitulina*)	C	X	
Black right whale (*Balaena glacialis*)*	F		X
Gray whale (*Eschrichtius robustus*)*	C	X	X
Minke whale (*Balaenoptera acutorostrata*)	C	X	X
Sei whale (*Balaenoptera borealis*)*	F	X	X
Fin whale (*Balaenoptera physalus*)*	F	X	X
Blue whale (*Balaenoptera musculus*)*	F		X
Humpback whale (*Megaptera novaeangliae*)*	C	X	X
North Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	F		X
Killer whale (*Orcinus orca*)	C	X	X
Harbor porpoise (*Phocoena phocoena*)	C	X	
Dall porpoise (*Phocoenoides dalli*)	C	X	X
Sperm whale (*Physeter catodon*)*	F		X
Bering Sea beaked whale (*Mesoplodon stejnegeri*)	F		X
Goose beaked whale (*Ziphius cavirostris*)	F		X
Northern right whale dolphin (*Lissodelphis borealis*)	F		X
Belukha (*Delphinapterus leucas*)	C	X	
Pacific giant bottlenose whale (*Berardius bairdi*)	F		X

* Endangered species (USDI 1979) C = commonly sighted F = few sightings

Sea lion

Steller sea lions (*Eumetopias jubatus*) can be found throughout the Lower Cook Inlet, Shelikof Strait area at all times of the year. They utilize seventeen different hauling areas and breeding rookeries on a regular, predictable basis (Table 2 and Fig. 2). Eight other locations are used as stop over areas where sea lions have been sighted irregularly (Table 3). Table 2 summarizes counts at all locations within Lower Cook Inlet and Shelikof Strait. These counts include only those made during the most recent photo surveys. It is important to remember that when considering sea lion numbers, only those sea lions which are hauled out or are in the water near a hauling area are counted. Many more animals are likely within the study area, but not associated with a specific hauling area at the time of the survey and therefore are not counted. The total numbers of sea lions within the study area fluctuates daily and the counts can only be used as a fractional indicator of this.

Steller sea lion populations within the lower Cook Inlet/Shelikof Striat OCS lease area are contiguous with and an integral part of the overall population of the north Gulf of Alaska. All of our evidence indicates no areas within the Gulf of Alaska have separate, distinct sea lion populations. Biochemical studies have shown that sea lions in the Gulf have extremely low genetic variation (Lidicker et al. 1979). Movements studies indicate they are highly mobile, capable of moving great distances and utilizing a variety of areas as haulouts. Sea lions marked within the study area have been sighted throughout the year both within the LCI/Shelikof area as well as throughout the rest of the Gulf of Alaska.

Table 2. Steller sea lion haulouts and rookeries located in Lower Cook Inlet and Shelikof Strait, with counts made 1957 through 1976. 1957 counts made by Mathisen and Lopp (1959).

Location	March 1957	June 1957	March 1976	June 1976	March 1977
Puale Bay 57°40'55"N 155°24'05"W			1,704	3,166	15,000+
Cape Iklolik 57°21'40"N 154°46'50"W			1,913	0	
Cape Ugat 57°52'20"N 153°50'45"W			222	0	
Takli Island 58°03'40"N 154°27'35"W			1,014	1,727	
Cape Gull 58°12'40"N 154°08'45"W			0	207	
Latax Rocks 58°41'25"N 152°29'00"W		3,334	322	1,164	
Rocks SW Sud Island 58°52'50"N 152°18'43"W			87	670	
Sud Island 58°53'00"N 153°15'00"W					
Ushagat Island SW 58°57'31"N 152°20'42"W	0	834	819	902	
Ushagat Island NW 58°57'31"N 152°20'42"W			0	106	
Sugarloaf Island 58°53'29"N 152°12'49"W	585	11,963	301	5,226	
Amatuli Island 58°55'20"N 152°02'30"W		1,576		57	
Nagahut Rocks 59°05'58"N 151°39'31"W			68	344	
Perl Island 59°05'58"N 151°39'31"W	12		8	33	
Cape Elizabeth 59°05'58"N 151°39'31"W	0				
E. Chugach Island 59°08'20"N 152°39'30"W	0	20	68	124	
Gore Point 59°10'47"N 150°57'50"W	0	200	200	535	

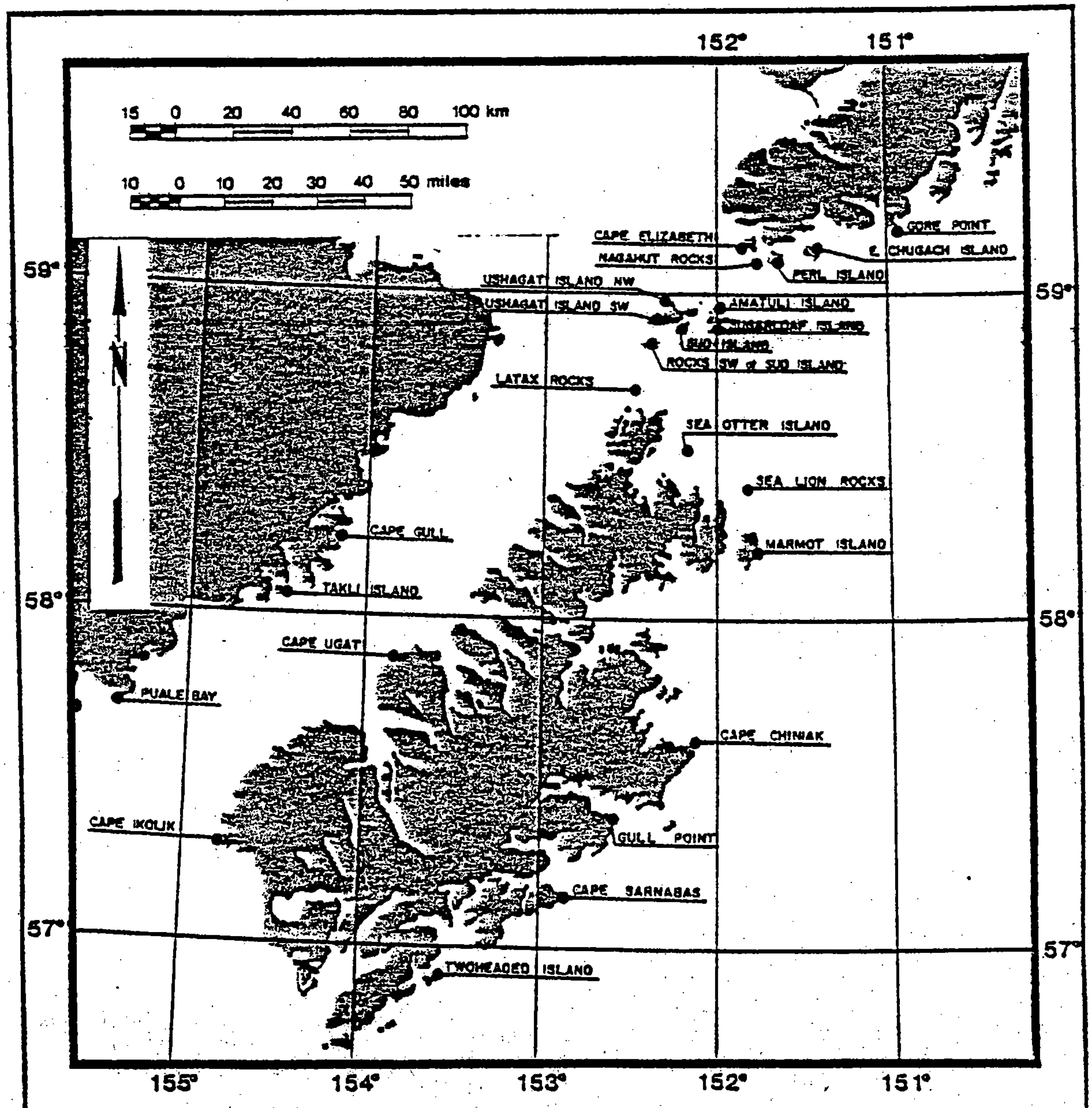

FIGURE 2. STELLER SEA LION HAULING AREAS IN THE LOWER COOK INLET / SHELIKOF STRAIT AREA.

Table 3. Location in Lower Cook Inlet and Shelikof Strait where Steller sea lions have been sighted, but which are not considered true hauling areas (Calkins and Pitcher 1977).

Name	Location	
	Latitude	Longitude
Sturgeon Head	57° 30' 30"N	154° 37' 50"W
Noisy Islands	57° 55' 30"N	153° 33' 00"W
Malina Point	58° 02' 30"N	153° 22' 00"W
Steep Cape	58° 12' 00"N	153° 12' 30"W
Cape Paramanof	58° 18' 15"N	153° 02' 45"W
Augustine Rocks	59° 13' 30"N	153° 22' 00"W
Cape Nukshak	58° 23' 30"N	153° 52' 50"W
Cape Ugyak	58° 16' 35"N	154° 06' 10"W

Sea lions often use some hauling areas on a seasonal basis only. Some areas are used primarily in winter, while others are used only during the summer breeding and pupping season. In the lower Cook Inlet/Shelikof Strait area, the most pronounced shift in seasonal distribution is found at Sugarloaf Island and at Puale Bay. These two areas are of key importance.

Sugarloaf Island is the only breeding rookery within the study areas and is the second largest breeding rookery in the northern Gulf of Alaska. Greater than 5,000 sea lion pups are produced here annually. This is approximately 20 percent of the total number of sea lion pups produced within the Gulf of Alaska each year.

Sea lion use of Sugarloaf Island is insignificant during the winter. Fewer than 500 sea lions remain on the island between December and March. By approximately mid April sea lions of both sexes and all ages begin hauling out on Sugarloaf Island. Near the end of April and the beginning of May large males begin to arrive at Sugarloaf and establish territories. Throughout May, pregnant females arrive in increasing numbers. Pupping begins approximately in mid May and continues through mid July. Pupping appears to peak between June 15 to June 25. By the end of June sea lions can be found all around Sugarloaf Island although the majority of pupping takes place on the north side of the Island.

During the middle of July, the large males' territorial structure begins to break down and they begin shifting about on the island and leaving. During this period the cows with older pups begin shifting along the shore as the pups lose their reluctance to enter the water. By the end of July nearly all pups readily enter the water. Adult females appear to remain on Sugarloaf with their pups until at least the end of October. Probably with the onset of winter storms in November they begin leaving the island. We know that sea lions move in all directions away from Sugarloaf Island in the winter. Sea lions born at Sugarloaf have been sighted at Cape Chiniak off Kodiak, Marmot Island off Afognak, Latax Rocks off Shuyak, Chirikof Island, the Semidi Islands, the Chiswell Islands on the Kenai Peninsula, Seal Rocks in the entrance to Prince William Sound and Cape St. Elias. Few of these animals return to Sugarloaf Island in the spring as subadults 2 and 3 years old. We do not yet know if pups born at Sugarloaf Island will return as adults to breed.

Puale Bay on the Alaska Peninsula in Shelikof Strait (Fig. 2) is probably one of the most important "hauling" areas in the northern Gulf of Alaska. This area is used by sea lions at all times, but as can be seen from Table 2 is most important during the winter. The sea lions use a group of rocks and small islands on the north side of the entrance to Puale Bay to haulout on. The largest group of sea lions seen here were sighted in March 1977. All traditional haulout areas were in use by sea lions. Several thousand other sea lions were resting nearby in the water. The reasons for this concentration of sea lions in the winter is not fully understood. We do know that sea lions born at Sugarloaf and Marmot Islands come here. In September 1978 this area was visited and a maximum of 2,000 sea lions, most of which were subadults were counted. At other times when visiting the Puale Bay haulout, the composition appeared to be all ages and both sexes.

Breeding in sea lions takes place shortly after pupping. Generally most of the pups are born at specific pupping rookeries although a few pups are born at other locations. Sugarloaf Island is the single major pupping rookery within the Cook Inlet/Shelikof Striat area with a few pups born at Puale Bay and possibly Takli Island. Breeding can take place at any location as cows of breeding age which are not pregnant do not necessarily return to these rookeries, but probably come into estrus even though they do not have a pup, and breed at whatever location they happen to be at the time.

Female sea lions are capable of breeding and becoming pregnant at 3 years of age. Age specific pregnancy rates for sea lions in the Gulf of

Alaska are approximately 21% for 3 years of age, 53% for 4 years, 57% for 5 years and 88% for ages 6 through 30. The oldest estimated age of a Steller sea lion taken in the Gulf of Alaska is 30 years. Although the sex ratio at birth is nearly equal, there appears to be a shift in the adult sex ratio with fewer males surviving to become members of the reproductive population.

Steller sea lions prey on a wide variety of fishes and cephalopods (Calkins and Pitcher 1978). Major prey items eaten by sea lions within and adjacent to lower Cook Inlet and Shelikof Strait study areas were capelin (*Mallotus villosus*), pollock (*Thergra chalcogramma*) and Pacific cod (*Gadus macrocephallus*). Octopus (*Octopus* sp.) was a major item by frequency of occurrence analysis, but was relatively unimportant by volume. Herring are undoubtedly important in the spring in Kamishak Bay during spawning, as large concentrations of sea lions have been sighted here when the herring are present.

Harbor Seal

Information on distribution and abundance of harbor seals is incomplete for the Cook Inlet-Shelikof Straits area. Studies specifically designed to collect these data have not been conducted. Information which is available is largely the result of incidental observations conducted during related studies in the area. Distributional data are particularly weak in upper Cook Inlet and the Alaska Peninsula coast of Shelikof Strait.

Figure 3 and Table 4 show locations and provide details of observations of major harbor seal concentrations in the area. Only sighting of 25 or more seals are included. This listing is incomplete and could undoubtedly be expanded with additional coverage. Particularly large hauling areas were found on Elizabeth Island, Yukon Island, Gull Island, Augustine Island and Shaw Island. There appear to be some seasonal changes in distribution of seals in the area. From May through September harbor seals are found in the upper Inlet even entering some river systems. They are absent during the winter months, probably moving to the lower Inlet. Seal movements coincide with movements of anadromous fishes including eulachon (*Thaleicthys pacificus*) and salmon (*Oncorynchus* spp.) into the upper Inlet. Also during some winters, heavy sea ice forms in Cook Inlet which may influence distribution. Harbor seals generally tend to use the ice edge for hauling out and are not found within areas with extensive ice cover.

Cook Inlet harbor seals may form a fairly discrete population as adult body size is significantly smaller than in nearby areas. Some interchange probably occurs from the Outer Kenai coast and the Alaska Peninsula coast of Shelikof Strait as distribution is continuous.

No data are available on population dynamics of Cook Inlet harbor seals. Information will be presented for seals from the Gulf of Alaska in the final report for RU 229 due for completion in October 1979. Timing of key life history events for harbor seals in Cook Inlet probably do not differ greatly from the Gulf of Alaska and are as follows: pupping—25 May to 25 June, nursing—25 May to 15 July, breeding—15 June to

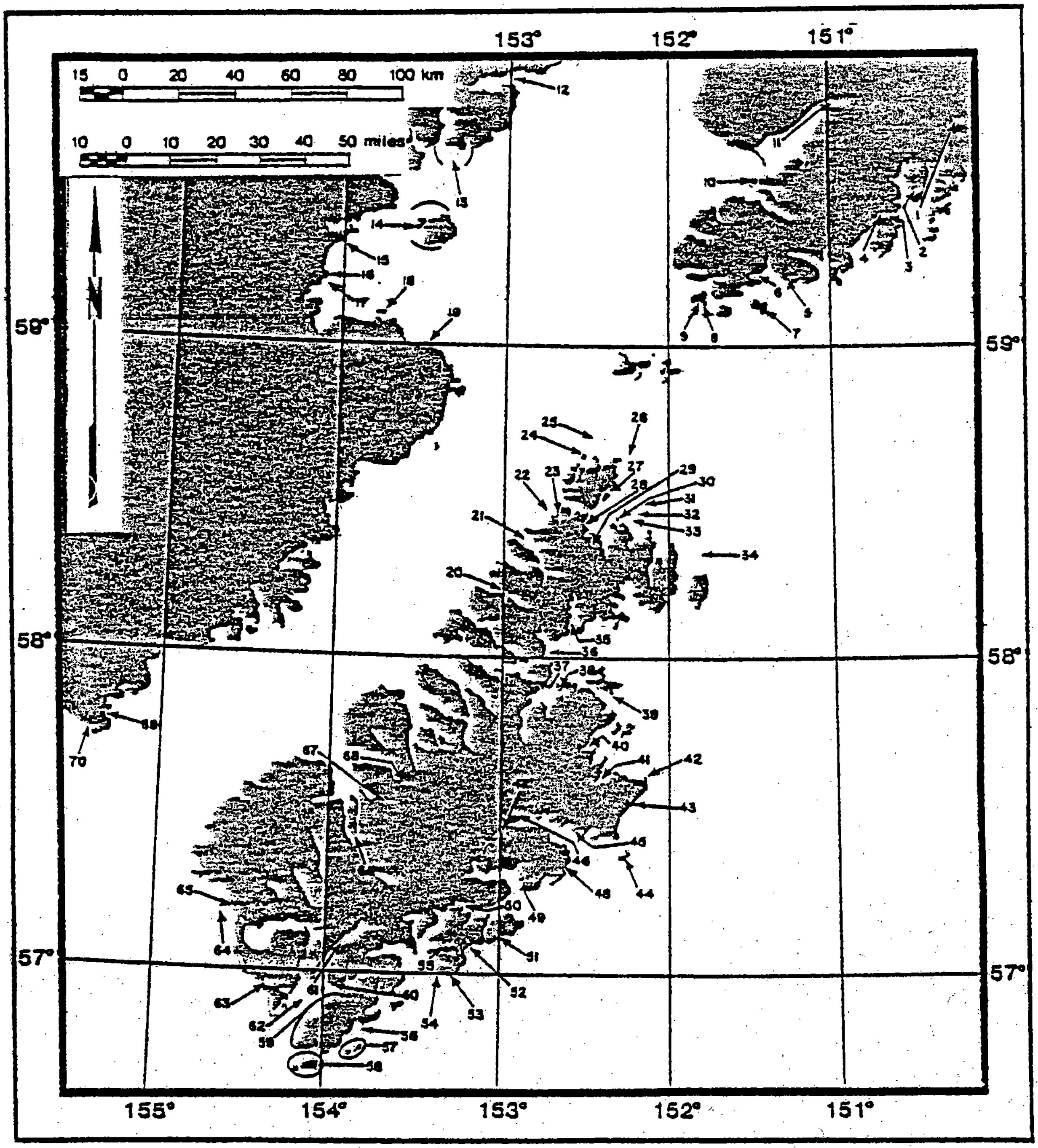

FIGURE 3. OBSERVATION LOCATIONS OF HARBOR SEALS IN THE LOWER COOK INLET / SHELIKOF STRAIT AREA. (SEE TABLE 4 FOR NUMBERS OF SEALS SIGHTED AT EACH LOCATION.)

Table 4. Partial listing of major harbor seal concentrations in Lower Cook Inlet and Shelikof Strait.

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
McCarty Arm 59 43 06 N 150 13 25 W	(1)	100	12 Nov. 1970	Hauled on glacial ice floes, ADF&G aerial survey
Suprise Cove 59 31 40 N 150 28 32 W	(2)	25	21 March 1977	ADF&G small boat survey
Division Island 59 25 23 N 150 41 50 W	(3)	50	6 June 1978	Hauled on intertidal rocks, ADF&G aerial survey
Nuka Island, NW 59 23 24 N 150 42 00 W	(4)	37	31 Aug. 1976	Hauled on intertidal rocks, Arneson (RU 003)
No Name Bay 59 14 07 N 151 17 25 W	(5)	176	24 June 1976	Arneson (RU 003)
Windy Bay 59 13 42 N 151 26 50 W	(6)	26	24 June 1976	Arneson (RU 003)
East Chugach Island 59 06 55 N 151 25 47 W	(7)	40	1 Oct. 1976	Hauled on sand beach, Arneson (RU 003)
Elizabeth Island 59 08 15 N 151 47 37 W 59 08 37 N 151 50 25 W	(8,9)	41-619	21 Aug. to 10 Sept. 1978	Hauled on gravel-cobble beach and intertidal rocks, ADF&G field camp daily counts
Yukon Island 59 31 37 N 151 30 20 W	(10)	250	30 Sept. 1976	Hauled on gravel beach, Arneson (RU 003)
Bradley-Fox River Flats 59 46 45 N 151 00 43 W	(11)	140	-	Arneson (RU 003)

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Gull Island 59 50 29 N 152 59 15 W	(12)	400	1 Oct. 1976	Arneson (RU 003)
Mouth Oil Bay to Mouth Iniskin Bay 59 37 32 N 153 24 15 W	(13)	200	Summer	Arneson (RU 003)
Augustine Island 59 20 08 N 153 32 55 W	(14)	850-1,500	30 Sept. 1976	Hauled out many locations along shore, Arneson (RU 003)
No Name Reef (Kamishak Bay) 59 17 30 N 153 53 07 W	(15)	200	8 April 1978	ADF&G small boat survey
Nordyke Island 59 10 57 N 154 05 22 W	(16)	109	15 July 1978	Arneson (RU 003)
Juma Reef 59 11 45 N 154 04 02 W	(17)	150	8 April 1978	ADF&G small boat survey
Douglas River Reefs 59 05 09 N 153 44 03 W	(18)	200		Sears and Zimmerman (1977)
Shaw Island 59 00 35 N 153 22 18 W	(19)	500-1,000	23 June 1978	ADF&G small boat survey
Malina Bay 58 11 35N 152 59 35 W	(20)	50	30 July 1978	ADF&G small boat survey
Foul Bay 58 21 45 N 152 52 00 W	(21)	40	30 July 1978	ADF&G small boat survey
Alligator Island 58 92 40 N 152 46 33 W	(22)	30	26 July 1978	ADF&G aerial survey
Blue Fox Bay 58 26 03 N 152 40 44 W	(23)	25	22 April 1976	ADF&G small boat survey

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Dark Island 58 39 00 N 152 31 50 W	(24)	45	12 June 1978	ADF&G aerial survey
Latax Rocks 58 40 15 N 152 30 45 W	(25)	175	26 July 1978	Hauled on rocky beach, ADF&G aerial survey
NE Shuyak Island, offshore rocks 58 35 31 N 152 16 43 W	(26)	25	12 June 1978	ADF&G aerial survey
Andreon Bay 58 30 36 N 152 23 33 W	(27)	25	April 1976	ADF&G small boat survey
Big Waterfall Bay 58 25 46 N 152 28 15 W	(28)	50	21 May 1977	ADF&G small boat survey
Phoenix Bay 58 22 07 N 152 28 20 W	(29)	25	22 May 1977	ADF&G small boat survey
Posliedni Pt. offshore rocks 58 26 48 N 152 18 08 W	(30)	60	14 June 1978	ADF&G aerial survey
Sea Otter Island area 58 30 33 N 152 10 25 W 58 29 48 N 152 16 28 W	(31)	30	12 June 1978	ADF&G aerial survey - nearby tidal rocks
Seal Bay-offshore rocks 58 24 13 N 152 12 04 W 58 23 35 N 152 10 14 W	(32)	35	22 May 1977	ADF&G aerial survey

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Seal Island 58 26 19 N 152 16 07 W	(33)	40	12 June 1978	ADF&G aerial survey
Sea Lion Rocks 58 21 00 N 151 47 45 W	(34)	34	6 Oct. 1975	ADF&G aerial survey
Kazakof Bay-offshore rocks 58 04 48 N 152 34 30 W	(35)	45	12 June 1978	ADF&G aerial survey
Hog Island group 58 00 15 N 152 41 01 W	(36)	160	12 June 1978	ADF&G aerial survey
Whale Passage 57 55 58 N 152 50 04 W	(37)	35	20 May 1977	ADF&G small boat survey
Anton Larsen Bay 57 53 15 N 152 39 27 W	(38)	25	20 May 1977	ADF&G small boat survey
Spruce Island-rocks off southeast tip 57 53 22 N 152 20 20 W	(39)	25	12 June 1978	ADF&G aerial survey
Womens Bay 57 42 40 N 152 31 42 W	(40)	31	1 March 1978	Arneson (RU 003)
Kalsin Bay 57 38 35 N 152 21 02 W	(41)	200	-	Sears and Zimmerman (1977)
Cape Chiniak 57 37 50 N 152 08 10 W	(42)	100	10 June 1978	ADF&G aerial survey, hauled on tidal rocks
Sacremento River-mainland beach 1 mile north 57 32 17 N 152 14 35 W	(43)	140	11 June 1978	ADF&G aerial survey hauled on gravel beach

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Ugak Island 57 22 18 N 152 16 15 W	(44)	1,600	29 July 1978	ADF&G aerial survey hauled on gravel beach
NE Ugak Bay-offshore rocks 57 25 50 N 152 33 50 W	(45)	410	24 July 1978	ADF&G aerial survey
Hidden Basin-entrance 57 30 12 N 152 54 40 W	(46)	107	1 March 1976	Arneson (RU 003)
Ugak Bay-head 57 26 43 N 153 01 04 W	(47)	200+	10 Nov. 1976	ADF&G small boat survey
Ugak Lagoon 57 20 06 N 152 38 15 W	(48)	50	6 Sept. 1978	ADF&G aerial survey, hauled on sand bar
NE Kiluda Bay 57 18 48 N 152 54 17 W	(49)	160	24 July 1978	ADF&G aerial survey
Sitkalidak Straits 57 12 07 N 153 10 37 W	(50)	35	2 May 1977	ADF&G small boat survey, hauled on tidal rocks
NE Sitkalidak-mouth lagoon 57 07 32 N 153 00 43 W	(51)	125	27 Aug. 1978	ADF&G aerial survey, hauled on sand bar
Ocean Beach 57 05 30 N 153 07 18 W	(52)	40	-	Sears and Zimmerman (1977)
Sitkalidak Island, Ocean Beach to Black Point 57 00 00 N 153 15 54 W	(53)	48	-	Sears and Zimmerman (1977)

Table 4 (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Puffin Island 57 00 25 N 153 21 11 W	(54)	90	27 Aug. 1978	ADF&G aerial survey
Natalia Bay 57 05 48 N 153 17 47 W	(55)	30	-	Sears and Zimmerman (1977)
Flat Island 56 49 53 N 153 44 20 W	(56)	100	27 July 1978	ADF&G aerial survey
Geese Islands 56 43 42 N 153 54 03 W	(57)	670	27 July 1978	ADF&G aerial survey
Aiaktalik-Sundstrom Islands 56 41 53 N 154 07 45 W	(58)	635	27 July 1978	ADF&G aerial survey
Aliulik Peninsula-west side 56 51 35 N 154 01 05 W	(59)	200	10 June 1978	ADF&G aerial survey, hauled on tidal rocks, many locations
Cape Hepburn 56 52 25 N 154 05 08 W	(60)	50	2 May 1977	ADF&G small boat survey, hauled on tidal rocks
Deadman Bay 57 04 18 N 154 56 38 W	(61)	100	-	Sears and Zimmerman (1977)
Middle Reef 56 54 36 N 154 02 28 W	(62)	150	2 May 1977	ADF&G small boat survey, hauled on tidal rocks
Sukhoi Lagoon 56 56 52 N 154 20 43 W	(63)	350	28 Aug. 1978	ADF&G aerial survey, hauled on sand bar
Ayakulik Island 57 13 03 N 154 35 00 W	(64)	75	-	Sears and Zimmerman (1977)

Table 4. (cont.)

Location	(Map No.)	Maximum number of seals observed	Date	Remarks
Ayakulik River 57 12 17 N 154 32 30 W	(65)	100	9 Oct. 1976	Hauled on mainland gravel beach, ADF&G aerial survey
Alf Island-Uyak Bay 57 24 45 N 153 49 50 W	(66)	250	1 Sept. 1978	Hauled on gravel spit, ADF&G aerial survey
Zachar Bay-Head 57 32 31 N 153 42 18 W	(67)	30	5 Nov. 1976	ADF&G small boat survey
Spiridon Bay-Head 57 36 50 N 153 35 41 W	(68)	50	5 Nov. 1976	ADF&G small boat survey
Alinchak Bay 57 45 50 N 155 15 00 W	(69)	200	16 June 1976	ADF&G aerial survey
Puale Bay 57 41 40 N	(70)	150	24 June 1978	Hauled on tidal rocks, ADF&G small boat survey

20 July, molting--late June to early October and implantation of the blastocyst--20 September to 1 November.

Sampling for food habit information in lower Cook Inlet was limited to two time periods 7-11 April and 22-23 June. Octopus (*Octopus* sp.) was the major item followed by shrimps, eulachon and capelin (*Mallotus villosus*) (Table 5). The most striking difference in prey utilization between lower Cook Inlet and the rest of the Gulf of Alaska was the dominance of invertebrates which formed 61% of the occurrences compared to only 26% for the Gulf of Alaska. Walleye pollock (*Theragra chalcogramma*), the dominant prey in the Gulf, was not encountered in our lower Cook Inlet sample.

Table 5. Prey of harbor seals collected from lower Cook Inlet. Total stomachs with contents = 17, total occurrences = 23, total volumes = 5,412 cc.

Prey	Percent of Occurrences with 95% C.L.	Percent of Volume
Octopus	39.1 ± 28.3	43.4
Shrimp	17.4 ± 18.6	30.6
Eulachon	21.7 ± 20.0	23.1
Capelin	8.7 ± 14.4	1.9

An index count area was established at the major hauling area on Elizabeth Island to provide a baseline to monitor trends in abundance of harbor seals in the area. Daily counts (Table 6) were made at low tide when maximum numbers of seals are usually hauled out.

Table 6. Elizabeth Island harbor seal count data, 21 August-10 September 1977.

Number of Seals	Number of Seals	Number of Seals
282	99	262
88	110	472
220	114	264
184	539	279
250	619	59
123	336	294
241	41	291
237	269	615

$\bar{x}$ with 95% confidence limit = 262.0 ± 69.8
Range = 41 - 619
Standard Deviation = 161.7

Sea Otter

Sea otters were eliminated from most of their original range in Cook Inlet by fur hunters during the 18th and 19th centuries. Remnant colonies probably remained in Prince William Sound and near Shuyak Island, Augustine Island and Sutwick Island. These colonies have grown and expanded their ranges into lower Cook Inlet during the past 15 years. Substantial areas of former sea otter habitat remain vacant or sparsely populated but all established groups of sea otters are continuing to grow. Habitat degredation has been limited to relatively small areas and sea otter densities should reach aboriginal levels during the next 10 to 20 years.

Sea otters currently inhabiting lower Cook Inlet and Shelikof Strait can be divided into four subpopulations. While these groups are relatively discrete, interchange between them is believed to occur and should increase as the subpopulations grow.

The following descriptions are based on data from Schneider (1976) and recent sightings:

1. Kenai Peninsula

   Sea otters probably were eliminated from the Kenai Peninsula by the early 1900's. Small numbers were occasionally reported between the Chugach Islands and Cape Puget in the 1950's and early 1960's but Kenyon (1969) concluded that no significant population occurred in the area. Reports increased steadily through the mid-1960's and in

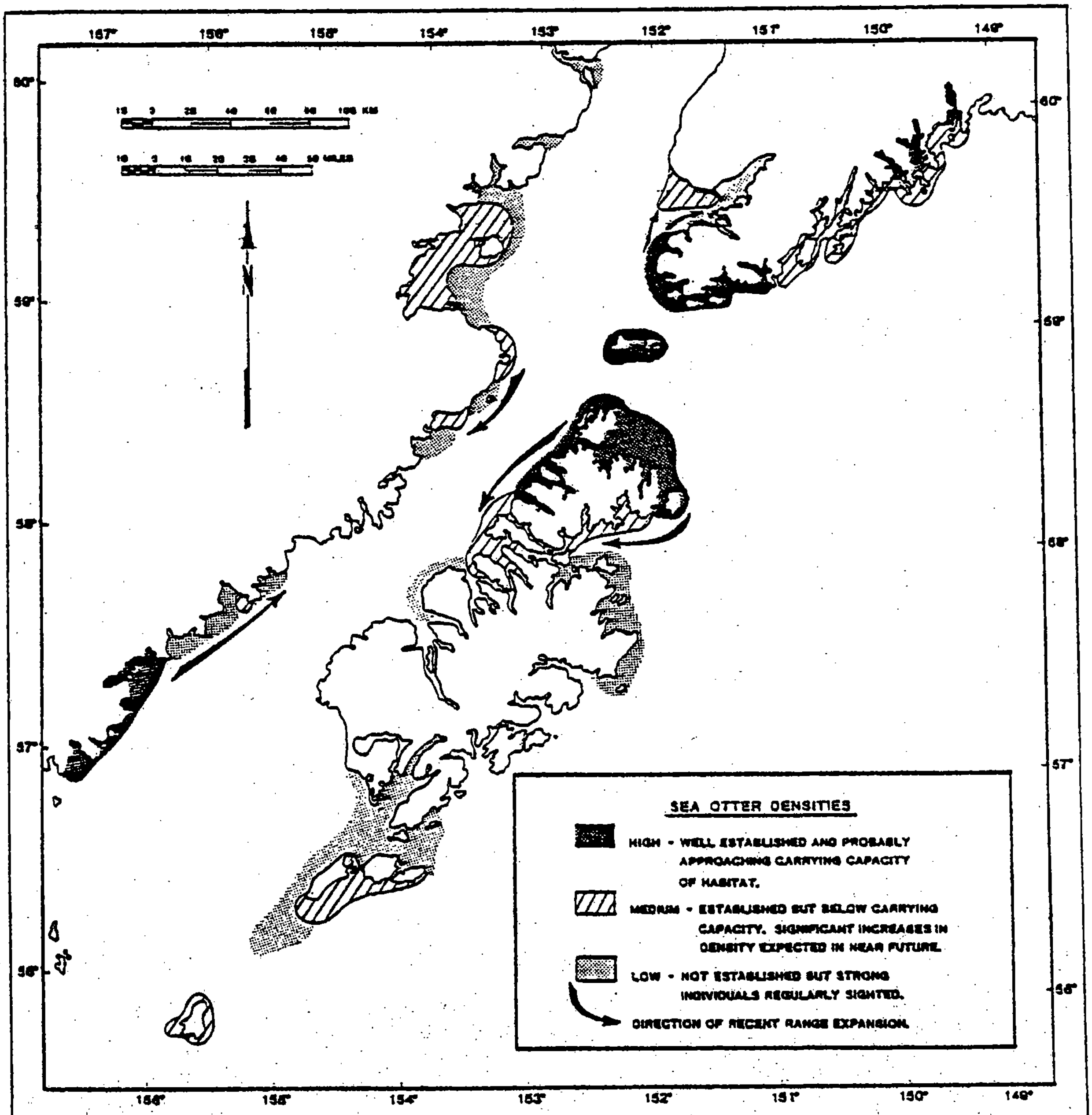

FIGURE 4. SEA OTTER DISTRIBUTION IN THE LOWER COOK INLET / SHELIKOF STRAIT LEASE AREA.

1967 several hundred and perhaps over 1,000 abruptly appeared in the vicinity of Port Graham and Chugach Bay. This concentration diminished over the next few years, perhaps as the result of dispersal to the east.

By 1970 sea otters were distributed in small numbers along the entire Peninsula from Cape Puget to Port Graham. Rare sightings occurred in Kachemak Bay. It appeared that repopulation was the result of range expansion by the Prince William Sound population and large scale immigration from another area, perhaps the Barren Islands.

At present the outer coast of the Peninsula from Gore Point to Port Graham appears fully repopulated. This subpopulation is expanding its range northward into Kachemak Bay and lower Cook Inlet. Stray animals occur throughout Kachemak Bay and several hundred inhabit a shallow offshore area west of Homer and south of Anchor Point. Occasional individuals have been sighted as far north as Clam Gulch. We can expect continued movement of animals from the outer Kenai Peninsula into Kachemak Bay and northward up Cook Inlet.

Kachemak Bay particularly the south side, should eventually support relatively high sea otter densities. Opportunities for the general public to view sea otters in Alaska are extremely limited. Kachemak Bay will probably eventually be one of the most accessible sea otter viewing areas in Alaska. Therefore, the importance of the bay and the sea otter population that will repopulate it is increased.

The potential for range expansion north of Kachemak Bay is less certain. Sea otters are capable of feeding in waters 80 m deep and in rare cases more than 100 m deep although most normally remain in water 60 m deep or less. Therefore, potential sea otter habitat extends across Cook Inlet and this population may become contiguous with that in Kamishak Bay. Food availability and perhaps the occurrence of sea ice will probably determine the eventual northern limit of this population. At this time it is difficult to predict what the northern limit will be. A recent sighting near Kalgin Island suggests that at least stray individuals may eventually occur throughout lower Cook Inlet.

2. Kamishak Bay

The history of sea otters in Kamishak Bay is vague. It appears that a small remnant population of sea otters remained there in the early 1900's. This population, centered around Augustine Island, probably grew throughout the 1940's and 1950's although no growth is evident in the counts. By 1965 some range expansion to the south had occurred. Counts made between 1969 and 1971 indicated that there may have been an increase in numbers around Augustine Island and the waters immediately to the north and west and that there had been a substantial movement around Cape Douglas to the vicinity of Shakun Rocks. The relatively high numbers seen by Prasil (1971) southwest of Cape Douglas suggest that the population within Kamishak Bay proper had reached a much higher level in the early 1960's than indicated by the counts.

Most likely, densities in the bay increased steadily through the 1960's then stabilized or declined slightly as animals emigrated to the southwest and possibly to the east across Cook Inlet. There is also a possibility that periodic oil spills influenced numbers although no direct evidence of oil related mortality is available from that area.

The available information indicates that the range of the population extends from northern Kamishak Bay to Cape Nukshak. Otters may occur throughout the shallow waters of Kamishak Bay and often range far from shore. The sea otters appear to be relatively mobile in this area and major shifts may occur periodically. Concentrations usually occur around Augustine Island, praticularly the north side; in the waters west of Augustine Island; around Shaw Island and Cape Douglas; at Douglas Reef; and at Shakun Rocks. Observed numbers in each of these areas have fluctuated widely, however. Sea otters inhabiting the Alaska Peninsula coast between Cape Douglas and Cape Chiniak should be considered part of the Kamishak population.

The population should continue to expand its range to the southwest. Eventually some range expansion to the north should occur.

3. <u>Kodiak Archipelago</u>

Three separate sea otter population centers exist in the Kodiak Archipelago. These are: (1) The Barren Islands (2) Shuyak-

Afognak and (3) Trinity Islands-Chirikof Island. The first two border on the lower Cook Inlet OCS lease area.

The Barren Islands were fully repopulated at least by 1957 when first surveyed. It is suspected that hundreds of sea otters migrated from the Barren Islands and Shuyak Island to the Kenai Peninsula during the mid 1960's.

At the present time this population can be considered at or near the carrying capacity of the habitat. Densities are highest in the shallow waters south of Ushagat Island including those around Carl Island and Sud Island. Low densities are usually found throughout the remainder of the island group. Little change is expected in the status of sea otters in the Barren Islands. Numbers may fluctuate but the distribution should remain similar to that observed in recent years.

A remnant population survived in the vicinity of Latax Rocks and Sea Otter Island near Shuyak Island. By the 1950's this population was well established and appeared to be growing rapidly, expanding its range to Afognak Island in the vicinity of Seal Bay.

Little change was evident in the 1960's. The range of the population remained the same although stray individuals were seen around Kodiak Island. No increase in numbers was evident. This apparent lack of increase may have resulted from emigration to the Kenai Peninsula, mortality from oil spills or been an artifact of survey techniques.

By 1970 the population was growing and rapid range expansion had occurred. In 1976 the primary range of the population extended from Shuyak Island south to Raspberry Island on the west side of the archipelago and to Marmot Island on the east side. The area between Ban Island and Marmot Island supported sea otter densities comparable to those anywhere in the world. High proportions of females with pups were observed throughout this area. Several hundred moved into Marmot Bay during 1977 and 1978.

Range expansion southward along both sides of the archipelago should continue at a rapid rate over the next few years. This will be most noticeable in Marmot and Chiniak Bays which appear to contain large areas of suitable sea otter habitat. The timing of this expansion is difficult to predict but it seems reasonable to expect moderate to high densities to build up in those areas in the next 5 to 10 years.

Eventually the population should become continuous with the Trinity Island population. Potential sea otter habitat on the northwest side of Kodiak Island north of Cape Ikolik appears limited and should require less time to become fully repopulated than the remainder of the island. We can expect a relatively sparse distribution of sea otters with a few small concentrations in areas such as the Noisy Islands, Chief Point and Harvester Island.

The southeast side of Kodiak Island has a number of broad shallow areas that will probably support large numbers of sea otters. The number of stray individuals and small groups in the area should grow over the next few years. Eventually increasing numbers of sea otters should move into the area, primarily from the north but also from the Trinity Islands. It may take many years for sea otters to reach carrying capacity throughout the entire area.

4. Alaska Peninsula

A large colony of sea otters has existed around Sutwick Island and Kujulik Bay for many years. During the 1960's this population extended its range northeastward to the vicinity of Wide Bay and a small group became established at Puale Bay.

No sea otter surveys have been made in the range of this subpopulation since 1970 however, incidental sightings indicate that the pattern of range expansion has continued. In June 1978 a minimum of 64 sea otters was seen at Puale Bay.

While this subpopulation resides outside of the lower Cook Inlet lease area it is evident that it will extend its range into Shelikof Strait and merge with the Kamishak Bay colony.

Available data are not adequate for reliable sea otter population estimates. However, the Alaska Department of Fish and Game has periodically projected rough estimates to indicate the approximate magnitude of sea otter numbers and the relative abundance among areas. The most recent estimates for the three subpopulations which could be directly impacted by leasing of lower Cook Inlet are: Kenai Peninsula--2,000 to 2,500, Kamishak Bay-Shelikof Strait--1,000 to 2,000, and Kodiak Archipelago--4,000 to 6,000.

The estimated sea otter population of Alaska is 105,000 to 140,000. Smaller natural populations exist in California and the USSR and transplanted groups remain in British Columbia, Washington and Oregon.

Sea otters tend to favor nearshore areas of shallow, rocky-bottomed habitat. Areas exposed to the open ocean but broken by reefs, islets and kelp beds are preferred. In such areas sea otters tend to range offshore to feed and move into kelp beds or the lee of rocks and islands to rest. In portions of their range they may haul out on beaches or intertidal rocks to rest. However, this picture of "classical" sea otter haibtat which has been described in most publications dealing with sea otter--community relationships can be misleading.

Sea otters apparently do not require nearshore areas, rocky bottoms, kelp beds or protected areas although they will use these when available. In some areas large numbers lead an almost pelagic existence ranging over 30 miles from shore where there are no exposed rocks or kelp beds.

Lower Cook Inlet contains both types of habitat and a wide variety of intermediate types. Often a heterogeneous mix of habitat types occurs within a small area. Since virtually all sea otter community studies have been conducted in areas that fall at one end of the spectrum, rocky habitat, and no studies have been conducted in lower Cook Inlet, only gross conclusions about the habitat requirements of sea otters in the lease area can be made.

The only obvious universal characteristic of all areas supporting moderate to high densities of sea otters is an abundant supply of accessible food. The available evidence indicates that sea otter populations at carrying capacity are generally food limited. Adult sea otters consume 3.5 to 6.5 kg of digestable food each day. Areas supporting high densities of sea otters must have prey populations capable of sustaining a yield of up to 30,000 kg/km^2/year. Sea otters are capable of using a wide variety of prey species. In some areas the high level of predation by sea otters has altered community structure. This in turn has forced sea otters to shift their food habits. Therefore the relationship between sea otters and food can be complex. It is clear that sea otter habitat must be highly productive of suitable food items, but at this time it can not be stated that any particular species of prey is critical in a particular area.

Water depth is a major factor limiting the availability of food and hence the distribution of sea otters. Almost all sea otter prey live in, on or near the bottom. There are records of individual sea otters diving to depths of 100 m but it is rare to see feeding sea otters in water deeper than 80 m. The highest concentrations of sea otters usually occur in waters less than 60 m deep.

Another important habitat characteristic is water quality. A major problem encountered in holding captive sea otters is providing clean water. When water becomes contaminated with food scraps, feces or oil the otters fur becomes soiled, looses its water repellency and the animal dies from hypothermia. While the need for clean water is well documented, no quantitative data are available to suggest how clean it must be.

In summary, while sea otters may have a number of specific habitat requirements they appear to be able to adapt to a wide variety of habitats provided large amounts of food are available, water depths are less than 80 m and preferably less than 60 m and the water is relatively clean. When the available food is reduced and water quality deteriorates a reduction in the capacity of the habitat to support sea otters will occur. At present there is no quantitative basis for assessing the quality of habitat in lower Cook Inlet. The patterns of sea otter distribution and range expansion suggest that the quality of habitat is highly variable from area to area.

Sea otters are not migratory and each individual tends to conduct major activities such as feeding, resting, breeding and pupping within the same general area. Therefore all of these critical activities occur throughout most of the habitat occupied by sea otters. However, there are areas where adult females tend to congregate and other sex and age classes are excluded to varying degrees. These "female areas" are probably the most critical sea otter habitat since they support almost all of the reproductively active animals. However, female areas tend to be extensive and include most of the habitat which supports medium to high sea otter densities. Therefore it is difficult to select a few small areas of "critical" sea otter habitat which merit special protection. Critical processes occur in virtually all areas that contain established sea otter populations. Unless extensive areas are protected the population will suffer.

Most information on sea otter reproduction was obtained from Aleutian populations that were near carrying capacity. There is some evidence of differences in timing of pupping and perhaps frequency of pregnancy in other areas. In the Aleutian populations studied, most female sea otters became sexually mature when 3 years old and produced their first pup when approximately 4 years old. Most females produced one pup every 2 years. It is possible that annual breeding occurs where populations are below carrying capacity but this has not been confirmed. Pup survival is high prior to weaning which may occur up to a year after birth. Survival remains good until old age in populations where food is not limiting but large numbers of recently weaned subadults die where food is limiting. This juvenile mortality appears to be a major population regulating mechanism.

Sea otters may live for more than 20 years but mortality rates of females over 15 years and males over 10 years appear high.

The sex ratio of the populations studied has been skewed in favor of females. This can result from a higher number of females being born, higher mortality among juvenile males, longer lifespan of females reaching adulthood and a greater tendency of males to disperse to sparsely populated habitat.

Therefore the sea otter's reproductive strategy is one of low productivity but high survival rates and long life. The behavior of the species seems adapted to providing adult females with the best opportunity to survive. This strategy is highly successful where sea otters are coping with most natural events that are likely to occur within their range. However, it is a poor strategy for resisting catastrophic events which kill both sexes all and age classes.

Belukha Whale

The Cook Inlet belukha population has been estimated by Klinkhart (1966) at 300 to 400. Recent survey conducted in the Inlet to determine distribution and abundance have not changed this estimate. Most surveys have involved shoreline observations and have not been intensive surveys of the open water areas of the Inlet. Accurate counting methods need to be developed so that a better population estimate will become available.

Fay (pers. comm.) feels the Cook Inlet belukha population could be a separate stock. A preliminary investigation of comparative crainial morphology indicated that the Cook Inlet belukhas may be taxonomically distinct from all other populations, perhaps as a consequence of long-term isolation in this area.

The Cook Inlet belukha population is thought to be resident in the Inlet year-round (Fay 1971; Klinkhart 1966; Scheffer 1973). Sighting data from 1976-1979 (Fig. 5) confirm that belukhas are present in all seasons in the Inlet.

Belukhas are seasonally distributed in the different regions of the Inlet. They have been sighted in the Upper Inlet primarily in late spring and summer. Belukhas are seen throughout the year in the central and lower Inlet, with heaviest use occurring in the central area.

Within the Inlet, numbers fluctuate seasonally, with the greatest number seen in mid to late summer and the fewest in winter. Ice conditions may have a strong correlation with winter abundance. In a winter of warm temperatures (1978) with little ice cover, belukhas were found in the central and lower Inlet. Whereas, in a winter of normally colder temperatures and extensive ice conditions (1979), few belukhas were observed. The location to which the belukhas go when and if they leave the Inlet in winter has not been determined. An aerial survey in March, 1979 turned up no belukhas in the neritic waters from Chignik Bay on the Alaska Peninsula to the mouth of Cook Inlet to the eastern extremity of Prince William Sound.

There is a paucity of information on breeding, calving and feeding concentrations of belukhas in Cook Inlet. Breeding whales have not been observed in the Inlet. Calving areas are not known; however, on aerial surveys in 1978 calves were observed at the Beluga River and in Trading and Redoubt Bays in mid-July. No calves were seen on the mid-June survey. Consequently, it appears that calving begins between mid-June and mid-July and may occur at the large river estuaries in the western upper Inlet. Calves were also observed in mid-August in the central Inlet between Kalgin Island and the Kasilof River and in mid-October in Tuxedni Bay.

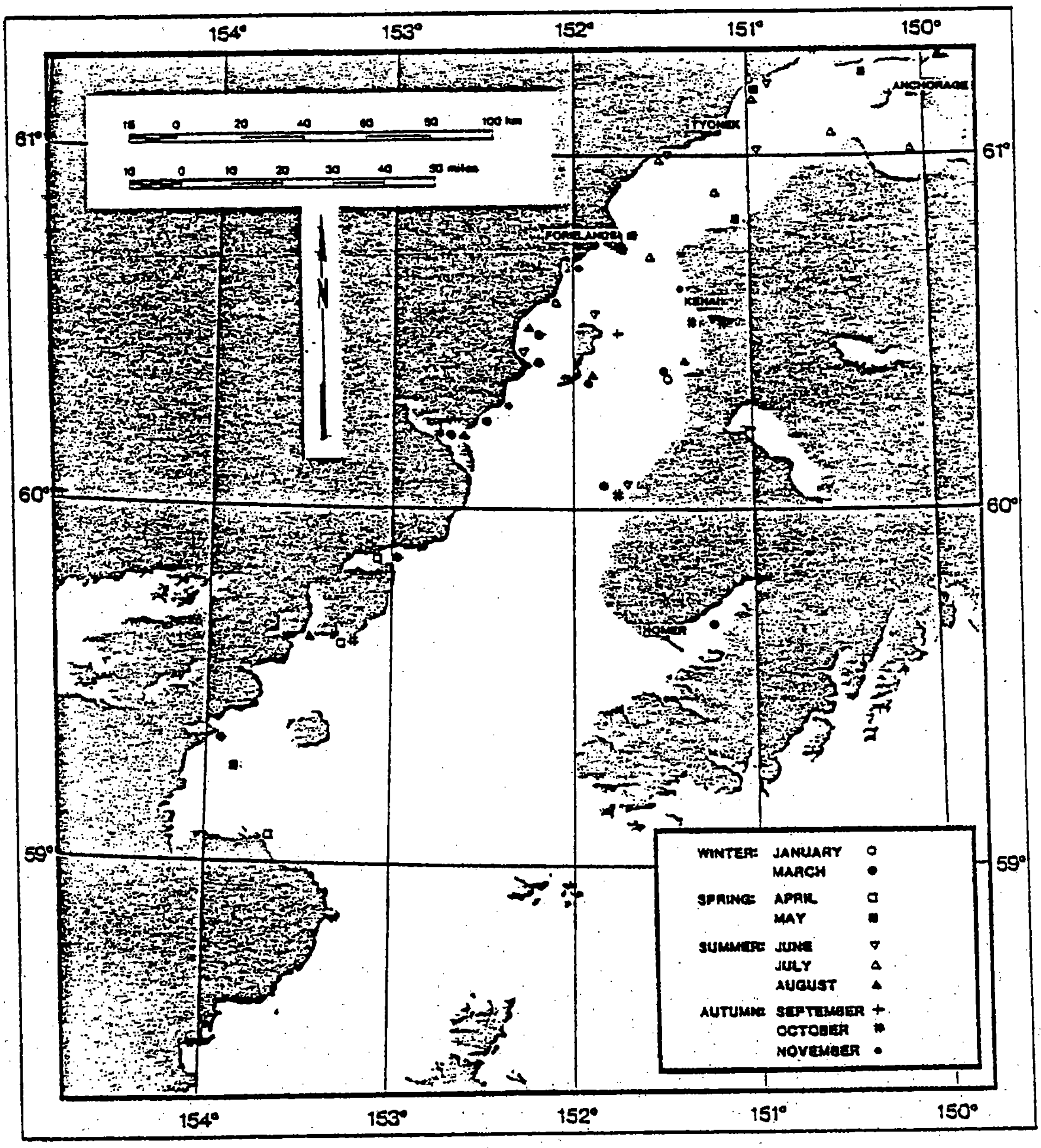

FIGURE 5. SEASONAL SIGHTINGS OF BELUKHA WHALES IN COOK INLET, 1976, 1977 AND 1978.

Concentrations were observed in mid-July at the mouth of the Beluga River and along the shoreline in Trading Bay, apparently feeding. The belukhas appeared to be eating fish caught close in to shore. These belukhas were in groups ranging from two to 25 animals. In mid-August a group of at least 150 whales was observed on three different days in the waters between Kalgin Island and the Kasilof River. The whales remained in this general area over at least a 4 day period. The whales were all aligned on the same directional heading with lead animals observed to break off from the front of the group. This behavior did not result in the remainder of the group changing its heading. Consequently, this type of large group formation most likely represents a feeding aggregation, although no feeding behavior (such as darting after a fish, etc.) or food source was directly observed.

Studies have been conducted on various aspects of the biology of belukha whales in several major arctic and subarctic concentration areas, but no study directly addressing the problem of habitat requirements has been undertaken.

The habitat types used by belukhas appear to fall into four categories: 1) migration routes, 2) feeding grounds, 3) breeding grounds, and 4) calving/nursery grounds. Food resources may be the critical element determining the interrelationship of habitat requirements. The habitat requirements vary seasonally and with the age and sex of the whale. The seasonal variations are dynamic and introduce difficulties in determining simple habitat requirements.

Migrations, whether extensive or localized, can be influenced by abiotic and biotic factors. Some authors consider ice dynamics to be of primary importance, while others contend that availability of food resources dominates. Kleinenberg et al. (1964) held that these factors act in combination. Ice conditions have a definite impact on the direction and timing of movements. Both the pattern of distribution and the abundance of whales are dominated by ice (Fay 1974; Fraker 1977). Although migratory patterns along the Alaska coast are poorly known, the presence of belukhas appears to be related to the movements of smelt, salmon smolts, and Arctic cod (Fiscus et al. 1976). Major surface current patterns in Cook Inlet would suggest that the most energetically efficient route to the upper Inlet would be along the eastern coast, while the route from the upper Inlet to the lower would be on the western coast. Seasonal distribution in the Inlet suggest that localized movements, most likely related to food resources and possibly calving ground areas, are critical to sustaining this population.

Feeding areas are determined and influenced by both biotic and abiotic factors. Concentration of food organisms is probably of major importance in determining where belukhas will feed. The biology and behavior of the food organisms plays a key role in their accessibility to the belukha. Ice dynamics affect the presence of food organisms in certain areas as well as influence the movements of belukhas. Other abiotic factors, including temperature, salinity, depth, sediment characteristics, and tides and currents not only affect the distribution of the belukha but the distribution of the belukhas' food resources as well.

The belukhas' characteristic summer movement inshore to river estuaries appears to be associated with concentrations of fish in these areas (Klinkhart 1966; Sergeant 1962; Tarasevich 1960). These whales also leave the estuarine areas to feed on pelagic fishes and invertebrates in the open sea and among the broken ice (Hay and McClung 1976). Belukhas also feed along the migration routes on patchy plankton and fish concentrations (Kleinenberg et al. 1964), indicating an overlap between migration route and feeding ground categories. Large herd formation is associated with heavy concentrations of food organisms in small feeding areas (Bel'kovich 1960). Fluctuations in food organism numbers, periodicity of occurrence, and seasonal inaccessibility cause irregularity of food resources for the belukha. This variability has likely resulted in selection for the broad feeding spectrum exhibited by these whales.

There is a lack of information on the belukha's breeding biology. Breeding grounds are unknown in Cook Inlet. Due to the timing of reproductive events, it is assumed here that breeding may occur along the migration route (overlap between categories) as the whales are approaching their summer feeding and calving grounds. It is also not known whether these whales feed while engaged in breeding activities.

While river estuaries are thought to be calving grounds, no births have been witnessed in these or any other areas. Recent evidence indicates that calves may be born outside the estuaries (Fraker 1977) and then move into these areas with their mothers (Hay and McClung 1976). Therefore, these areas might be considered more appropriately as nursery grounds.

Estuarine areas maybe important to newborn calves due to the higher temperatures which "may lessen the shock of birth and reduce heat loss in the first few days until the young animal has acquired some subcutaneous fat" (Sergeant 1973). Fraker (1977) also emphasized water temperature as the key factor in selection of these areas. He found that at the time of their use by large numbers of whales, these river estuaries had high temperatures, high turbidities, low salinities and shallow depths. All age classes congregate in the estuaries during the calving period. Fraker (1977) hypothesized that all age classes benefit from the thermal advantages, but that newborn calves would benefit the most from this advantage due to their small surface-to-volume ratio and limited fat deposits. Food resources have not been investigated in these areas, so it is possible that juvenile and adult whales may be feeding while in the calving/nursery grounds.

There is little information available at present on the seasonal use of specific habitat categories for the Cook Inlet population. Localized migrations occur throughout the Inlet during the year and may extend outside the Inlet into Shelikof Strait or possibly as far away as Yakutat Bay in the winter. Since food resources are likely the primary influence on localized migrations, the Cook Inlet belukhas are probably feeding in most areas where they are found. There are likely to be shifts in food items correlated with season and location. If Cook Inlet belukhas are breeding in May and or June, this activity is most likely occurring in the Upper Inlet. Calving/nursery grounds would be occupied in early to mid summer. The large river estuaries in the northwest Inlet (from Susitna River to Trading Bay) are probably the primary location for these activities. In summary, the Cook Inlet belukhas range widely throughout the Inlet making seasonal use of specific habitat areas and food resources.

Mating behavior has not been observed in belukhas. Sexual maturity is reached in the female at an age of five years and in the male at about eight years (Brodie 1971). Strong pair bonding between any one male and female is unlikely, since trios of two adults and a calf are not observed (Fraker 1977). This also appears to be the case for the Cook Inlet belukhas. Although Vladykov (1946) states that breeding occurs from April to June and Doan and Douglas (1953) state that breeding can occur later in the summer, the general concensus is that a breeding peak occurs in May (Brodie 1971; Doan and Douglas 1953; Vladykov 1946). Klinkhart (1966) states that all adult males taken from the Bristol Bay population from May to September were in reproductive condition. However, a short peak of calving for this population suggested that breeding was confined to a relatively short period in May or June. This timing may also be found for the Cook Inlet population.

Belukhas have a three year reproductive cycle (Brodie 1971). The gestation period is about 14 months (Sergeant 1962 and 1973). The breeding period occurs approximately 2 months prior to the calving period. Assuming that breeding occurs in May, Brodie (1971) found that females gave birth approximately 14 months later, in late July and early August. Lactation lasted for the next 21 months, indicating an almost 2 year period of nursing.

Reproductive rates have not been calculated for any population. However, assuming an average life span of 32 years (Kleinenberg et al. 1964) with the onset of maturity in the female at 5 years and a 3 year period between calving, a female would have an average of nine calves over her life span.

The sex and age structure has not been determined for the Cook Inlet population. Males cannot be easily differentiated from females. However, color differentiation can be made between juveniles and adults, since attainment of white coloration corresponds to sexual maturity. In the large concentration observed in August 1978, approximately one of seven whales was a juvenile.

Mortality factors include predation, parasites, diseases, and hunting. The only natural predator of the belukha known to occur in Cook Inlet is the killer whale, *Orcinus orca*. Killer whales are seen only in the lower Inlet in summer. Since the belukhas are generally in the central and upper Inlet areas during this time, there is probably little loss of belukhas to killer whale predation.

Endoparasites found in the belukha include acanthocephalans, trematodes, cestodes and nematodes (Kleinenberg et al. 1964; Klinkhart 1966). Their effects on the belukha are unknown. The occurrence of these parasites in Cook Inlet belukhas has not been studied. Other diseases are unknown in belukha populations.

Hunting of the Cook Inlet belukhas has not taken place since the 1960's. However, belukhas found near fishing nets and vessels are occasionally shot and killed. There are not figures on the frequency of occurrence of whales killed in this manner.

Food Habits

The belukha has the broadest feeding spectrum of any whale. Their food resources include a variety of fishes and various kinds of octopus, squid, crab, shrimp, clams, snails, and sand worms (Fay 1971). The maximum size of food organisms is limited by the capacity of the esophagus, since food items are swallowed whole (Fay 1971; Fraker 1977). Kleinenberg et al. (1964) state that belukhas do not feed on deep water organisms.

The preferred food organisms of the belukha in Cook Inlet in the summer appear to be the osmerids and salmonids. Belukhas caught in Bristol Bay and Cook Inlet during the summer were found to contain salmon, smelt, flounder, sole, sculpin, and shrimp. Data for the upper Inlet are not available. Possible foods for the belukha in the Kachemak Bay area are shrimp, crab, halibut, sole and herring. There appears to be a circulation gyre around Kalgin Island; this area, although uncharacterized for the most part, may be rich in food resources. Crustaceans are known to occur in the southern Kalgin Island region.

The food of the belukha can be expected to vary seasonally and with location. During the spring and summer, the Cook Inlet belukhas probably feed on salmon smolts migrating from river estuaries and herring moving to and from spawning grounds as well as heavy concentrations of adult salmon schooling off the river mouths. Throughout the summer, belukhas may switch from one salmon species to the next. King salmon run earliest in the Inlet with reds, pinks, chum and silvers following in that order. In the fall-winter season belukhas may eat smelt, bottom fishes and invertebrates. In the spring belukhas are found near concentrations of smelt.

Sergeant and Brodie (1969) suggest that productivity of the winter environment is critical in determining the adult size of belukhas in different regions. They suggest that "Selection has reduced the biomass of an individual white whale to that enabling it to maintain its metabolic activity on the available food." Further, "there appears to be no gross difference in numbers of white whales between trophically suboptimal and more suitable environments; the difference is expressed in individual biomass."

The food of the belukha also varies with age and sex. Lactation lasts about 2 years in belukha (Brodie 1971; Sergeant 1973). Young of the year feed only on milk, while yearlings supplement the milk by feeding on capelin, sand lance, shrimp, and small bottom dwelling crustacea (Brodie 1971; Kleinenberg et al. 1964; Sergeant 1962). The food of subadults is similar to the diet of adult animals. Adult males feed primarily on large fish while females prefer food items such as sand lance, octopus and particularly *Nereis* (Kleinbert et al. 1964). Fluctuations in food organism numbers, periodicity of occurrence, and seasonal inaccessibility cause irregularity of food resources for the belukha. This may have caused the belukha not only to widen its feeding spectrum but to differentiate food habits by age and sex. This differentiation enables the belukha to successfully utilize the available food (Kleinenberg et al. 1964).

Behavior

Possible feeding behavior of belukhas has only been observed on two occassions during aerial surveys in Cook Inlet. Near shore feeding groups appear to consists of small aggregations of belukhas randomly aligned with respect to one another. Whales were seen lying at the surface facing the shore; individuals pitched forward in the water such that only the flukes were visible at the sruface and then pitched back to the original position. The whales appeared to be operating individually in their efforts to catch food.

Groups of migrating belukhas vary in number and composition of whales. Most groups contain a predominance of adults with a few juveniles. Generally the animals are closely spaced, although a widely scattered group on which all individuals had the same directional heading was observed in March 1979. In groups of 10 to 30 animals, all whales do not surface simultaneously. Instead, there is usually a wave of three groups: the first group surfaces; as it is beginning to submerge, the second group surfaces; as this group is beginning to submerge, the third group surfaces; this is closely followed by the first group surfacing while the third is still at the surface. Calves closely follow their mother's movements and on all occassions were seen to the left rear side of the adult.

Humpback Whale

Humpback whales are the most common of the large, dorsal finned whales found in the Gulf of Alaska (Calkins et al. 1975), with a minimum of 60 individuals found in the Gulf of Alaska adjacent to Cook Inlet (Fiscus et al. 1976). Humpbacks are migratory, spending April through December in the Gulf. The area south of Kodiak Island may be relatively important since whales are frequently sighted there (Fiscus et al. 1976). Relatively large concentrations of humpbacks have been sighted in September in the area just northwest of Shuyak Island and south of the Barren Islands. Humpback whales are commonly sighted in the Barren Islands and the southern tip of the Kenai Peninsula.

Humpbacks are surface feeders, feeding mostly on euphausiids, although they will occassionally eat fish such as herring (*Clupea harengus*), cod (*Gadus* spp.) and salmon (*Onchorhynchus* spp.) (Wolman 1978).

Gray Whale

The gray whale population probably numbers greater than 11,000 animals (Rice and Wolman 1971). Nearly all of these are known to migrate through the Gulf of Alaska from May through November to feed in the waters of the Bering and Chukchi seas (Calkins et al. 1975). Gray whales generally travel near the coast (Rice and Wolman 1971). When migrating through the study area the whales apparently follow the east coast of the Kenai Peninsula and then turn southwest at the Barren Islands and move along the east coast of Afognak and Kodiak Islands (Cunningham ms).

Although gray whales appear to abstain from feeding on their migration along the California coast there is no quantitative data available to verify this behavior for whales in the Gulf of Alaska. There is some indication that whales may feed in the Gulf since Cunningham (1979) observed what appeared to be feeding behavior near Kayak Island. Similar behavior has been observed in the Barren Islands.

Minke Whale

The minke whale is migratory and found in the study area during the summer months where it frequents the near-shore habitat. Numerous sightings have been recorded in Kachemak Bay during August (Fiscus et al. 1976).

Minke feed on small schooling fish such as sandlance (*Ammodytes hexapterus*) and herring, euphausiids and other invertebrates (Mitchell 1978) and are known to concentrate in areas where food is abundant.

Killer Whale

Killer whales are found throughout the Gulf of Alaska during the summer months and may shift south in the winter (Leatherwood et al. 1972). They tend to prefer shallow water and generally stay within 200 miles of shore (Fiscus et al. 1976).

Killer whales feed on pinnipeds, porpoises, whales, cephalapods and fish (Fiscus et al. 1976, Rice 1968) with adult males feeding predominantly on marine mammals (Rice 1968). This species generally hunts in groups, especially when feeding on marine mammals (Fiscus et al. 1976). Groups of up to 10 individuals are common, with groups of up to 500 reported in the Gulf of Alaska (Calkins et al. 1975). Killer whales have been observed in Cook Inlet near the Kenai Peninsula and in deep water.

Dall Porpoise

The Dall porpoise is probably the most common cetacean in the Gulf of Alaska and is found both near shore and offshore (Calkins et al. 1975). This species appears to prefer channels between islands and wide straits where ocean currents meet (Fiscus et al. 1976). Dall porpoise can be encountered anywhere within Lower Cook Inlet.

Feeding is known to occur at considerable depths where prey such as hake (*Urophycis* spp.), lantern fish (*Myctophidae*) and squid are taken (Leatherwood and Reeves 1978).

Harbor Porpoise

Harbor porpoises are the smallest cetacean in the Gulf of Alaska (Calkins et al. 1975). They are common in bays, estuaries, tidal channels and harbors (Calkins et al. 1975, Fiscus et al. 1976) and usually confine their activities to waters of less than 18 meters (Leatherwood and Reeves 1978). This species is wary and easily disturbed by boat traffic.

Its food habits include small fish and cephalapods such as herring and squid (Leatherwood and Reeves 1978). Harbor porpoise use nearly all shallow waters of Lower Cook Inlet.

Terrestrial Mammals

Although this report deals mainly with marine mammals, this section highlights aspects of certain terrestrial mammals which utilize the marine environment to a significant degree. These species include river otter (*Lutra canadensis*), mink (*Mustela vison*), brown bear (*Ursus arctos*), Sitka black-tailed deer (*Odocoileus hemionus*) and red fox (*Vulpes fulva*).

River otters are distributed throughout the lower Cook Inlet region and along both shores of Shelikof Strait. Mink distributions are similar, except for their absence from Kodiak Island. Little information is available on densities, although it appears that otter densities are low along the eastern shore of the Kenai Peninsula and high along the south shore of Kachemak Bay and throughout Kodiak Island. There is no data for otters in other areas nor is there data anywhere in the area for mink (ADF&G 1978b).

River otters commonly utilize shallow coastal waters for hunting and travel. The effects of oil on river otters is unknown, but may be similar to sea otters since they also rely on their pelage for insulation (Kooyman et al. 1977). Although there is little information on food habits in the study area, it appears likely that the majority of prey will consist of small fish and crustaceans (Toweill 1974) which would be susceptable to oil pollution. There is no data available on the ability of otters to detect and avoid oil slicks or contaminated prey.

Mink similarly use the coastal region. There is no information on the effects of oil on mink. They are known to use the narrow strip of snow free beach during winter months in southeast Alaska (Harbo 1958), where they feed on mussels (*Mytilus edulis*), clams (*Siliqua* spp.), sea urchins (*Strongylocentrotus* spp.) and Dungeness crabs (*Cancer magister*). Snow conditions are similar in the study area and one would expect concentrated activity along the beaches in the winter. Oil spills in the winter could contaminate much of the available habitat as well as eliminate what could be potentially crucial winter food sources.

Brown bears inhabit Kodiak Island and all of the mainland within the study area except the region south of Kachemak Bay (USDI 1976). A minimum estimate of 500-600 bears inhabit the western side of Cook Inlet (J. Faro pers. comm.) and 1000-1500 bears inhabit the western drainages of Kodiak Island (R. Smith pers. comm.).

Bears use the coastal beaches from April through November, but are most frequently found during spring, with June probably the most important month (L. Glenn pers. comm.). Bears travel the beaches searching for newly emergent grasses, sedge and herbaceous plants, carrion and invertebrates. Coastal sedge meadows are also important feeding areas. Later in the summer and fall bears feed inland on either salmon or berries and are less likely to be exposed to oil spills.

Bears could be impacted by oil spills in several ways. Acute spills in the spring could inundate marshes and beaches, which would either force bears to avoid feeding areas, causing increased competition for the limited food resourca during that season or expose them to oil ingestion from contaminated food. Bears may not avoid oil (Hanna 1963) and thus be susceptable to contamination of their pelage. Bears oiled prior to denning may be impacted by a reduction in the insulating quality of the fur during hibernation. Contamination of newborn cubs could also result.

Sitka black-tailed deer are found on Kodiak, Afognak and Raspberry Islands. There may be 5,000 to 10,000 deer in the western drainages of Kodiak (R. Smith pers. comm.). Deer tend to concentrate on the outer capes during winter where they feed on kelp. During severe winters the beach may provide the bulk of available forage to deer (R. Smith pers. comm.).

Spills during severe winters could contaminate the majority of available forage, causing increased competition for the remaining food items, ingestion of oil and possible starvation. Should deer become oiled then the reduction in the insulating quality of the fur would lead to increased energy consumption. The increased energy demands may become critical during winter months.

Red fox are found throughout the study area and are known to hunt along the beaches for amphipods, clams, crabs, stranded fish and carrion (USDI 1976). It appears that foxes utilize the beaches on islands more than the mainland (USDI 1976), and increase their use during winter (R. Smith pers. comm.). Fox are known to eat oiled birds and mammals (Hanna 1963) and were numerous on the beaches after a spill in Cook Inlet in 1969 (USDI 1976). The consequences of an oil spill on red fox are largely unknown.

POTENTIAL FOR IMPACT FROM OCS OIL AND GAS EXPLORATION, DEVELOPMENT AND PRODUCTION

ACUTE OIL SPILLS

Oil Spill Source

Leaks at drilling platforms, oil well blowouts, major pipeline breaks, tanker spills and spills at tanker terminals are all potential sources of acute oil spills in Cook Inlet. These spills will fall into two major categories: underwater spills from pipelines and oil well blowouts and surface spills from drilling platforms and tankers.

Oil Spill Transport

The major factors which contribute to the transport of oil after an acute spill are wind, net circulation, tidal currents, surface spreading, mixing and winter ice accumulations (ADF&G 1978a).

Wind induced transport is frequently the most influential factor (ADF&G 1978a) usually moving a slick at about 3 percent of the wind velocity (Dames and Moore 1976). Drogue studies have indicated that wind speeds greater than 5 m/sec will become the dominant influencing factor (Burbank 1977). Higher and persistant winds can also alter the net circulation itself, thus increasing the magnitude of the surface transport of oil (ADF&G 1978a).

The net circulation and tidal currents are important dispersing mechanisms for oil, especially under calm conditions and when the oil is incorporated into the water column. Of the two, the net circulation is more sluggish and is superimposed on the oscillatory tidal movements; thus the net trajectory of oil introduced into the water at a particular location is dependent on the stage of the tide at that time (ADF&G 1978a).

The spreading of oil across the water's surface will enlarge the size of the oil slick, and in areas of minimal circulation, such as a gyre in a bay, may be an important factor in determining the affected area (ADF&G 1978a). Spreading speeds up the weathering process by increasing the surface area exposed to the air and seawater (McAuliffe 1977).

The transport of oil may differ depending on the degree of mixing. Oil layered on the water's surface can be affected by wind and currents while oil incorporated into the water column by wave action or underwater spills will be transported primarily by currents.

Winter ice will act as a temporary barrier to slicks. Eventually oil will become incorporated with the ice (Milne 1977) and be transported along with it.

Crude Oil Composition

The behavior of crude oil once it is spilled is largely determined by the complex nature of its composition. The bulk of crude oil is composed of hydrocarbons, which can be placed in three classes of compounds: parafinic, naphthenic and aromatic (Evans and Rice 1974). A brief summary of their characteristics will aid in understanding the ultimate fate of crude oil:

Parafinic compounds are straight chained hydrocarbons of high molecular weight and relatively low toxicity (Evans and Rice 1974). They tend to make up the more persistant portion of crude oil due to their insolubility and high viscosity. The commonly observed tar balls are composed mainly of parafinic compounds.

Napthenic compounds contain at least one saturated ring structure. They can combine with other compounds to form complex molecules.

Aromatic compounds contain unsatuarated ring structures. They are of a relatively low molecular weight, are highly volatile, relatively water soluable and are highly toxic (Evans and Rice 1974). Since toxicity increases with molecular weight and solubility decreases, the compounds likely to cause the greatest harm probably have weights somewhere in the middle (Rice et al. 1975). Some aromatic compounds are also known cancer causing agents (Blumar et al. 1970).

Fate of Crude Oil

The fate of crude oil after a spill is governed by various physical, chemical and biological processes. These processes include evaporation, dissolution, emulsification, biodegredation, adsorption, mixing, sinking and human induced chemical dispersion.

One of the first major changes in an oil spill is the loss of the highly volatile aromatics through evaporation and dissolution. The evaporation rate would depend on the water and air temperature, the amount of radiant energy impinging on the slick and the wind speed. High winds would aid evaporation on one hand, but also increase the amount of dissolved aromatics through increased water turbulance. Cook Inlet crude has a high content of volatile aromatic hydrocarbons and visible evidence of a slick may be gone within several days (Kinney et al. 1969).

Should an oil spill occur due to an underwater pipeline break or an oil well blowout one would expect an increase in the amount of aromatics in solution as compared to a surface spill (McAuliffe 1977). Indeed, in a blowout situation the turbulance of the oil being expulsed would tend to emulsify the oil particles (Milne 1977) and probably increase the amount of aromatics in solution. Thus, an underwater oilwell blowout could be an increased source of dissolved aromatics which would be available for uptake by organisms.

Spills during periods of strong winds would tend to be emulsified. The composition of the oil droplets suspended in the water would be affected by the type of mixing. Violent mixing would tend to encorporate dispersed droplets similar to the parent oil while slower mixing would only incorporate the more soluable portions (Rice et al. 1975). Once oil is dispersed and no longer observable as a surface slick it will principally remain near the surface (McAuliffe 1977).

Emulsified oil provides greater surface area for biodegradation to occur (Kinney et al. 1969), although most microbial action is on the less toxic parafinic compounds (Evans and Rice 1974, Gibson 1977). Emulsion also allows for increased adsorption to suspended particles which aids in biodegredation and transport to the sea floor (McAuliffe 1977). Although Cook Inlet has a heavy sediment load in some regions, Kinney et al. (1969) found that it had no apparent effect on Cook Inlet crude oil.

The viscosity of the oil also effects the amount of oil entering the water phase (Rice et al. 1975) since more energy is needed to mix more viscous oil. Cook Inlet crude is relatively thin, having twice the water soluable fraction as Prudhoe Bay crude (Rice et al. 1976).

Oil that reaches shore will become incorporated into beach sediments to varying depths depending on the substrate (Evans and Rice 1974). This oil may persist indefinitely due to the absence of oxygen needed for its degredation (Boesch 1973).

Some oil fractions have densities approaching that of water and will sink directly to the bottom (Evans and Rice 1974). Photo oxidation changes some compounds into polar hydrocarbons which are water soluable and thus add to the concentration in the water column (Winters et al. 1976). Salinity and pH will also affect the amount of oil which will dissolve in the water (Rice et al. 1975).

The use of chemical dispersants to form oil-in-water emulsions can markedly alter the fate and effects of an oil spill. The emulsifying agent or surfactant is a compound which is soluble in water at one end and soluble in oil at the other (McAuliffe 1977). When mixed with an oil it forms a stable oil-in-water emulsion which, due to the surfactant's chemical properties, will not coalesce and decreases the adhering properties on rocks, sand and marine organisms (McAuliffee 1977).

Dispersants have been shown to be quite toxic in some instances (Dorrler 1977, Lonning and Hagstrom 1976). A major portion of the dispersant is a solvent, which, depending on the particular brand, may be a highly toxic aromatic hydrocarbon (Dorrler 1977). Dispersants have been shown to increase the toxicity of oil by making it more readily available for uptake (Canevari and Lindblom 1975, Tarzwell 1970), and by enhancing the movement across the gill structure in fish (McKeown and March 1978). Since dispersants can emulsify a wide range of molecular weights of hydrocarbons (McAuliffe 1977) it appears that if a fresh oil spill was dispersed it would incorporate toxic aromatic compounds into the water column which may otherwise have evaporated.

THE EFFECTS OF ACUTE OIL SPILLS ON MARINE MAMMALS - A REVIEW

The effects of oil on marine mammals is still only partially understood. The potential impacts are related to the biological characteristics of the species. The impact of oil on sea otters, fur seals, phocid seals and sea lions and cetaceans are reviewed separately.

Sea Otter

The behavior, physiology and morphology of the sea otter combine to make it the marine mammal most vulnerable to direct oil pollution (Schneider 1976).

Sea otters rely on air trapped within their dense fur for insulation (Barabash-Nikiforov et al. 1947, Kenyon 1972a). The fur is kept clean and water repellent by grooming, an activity which normally may take up to 10 percent of an otter's time (Calkins 1972). After being contaminated with oil, otters have been observed spending up to 75 percent of their time grooming (Williams 1978). Grooming is accomplished primarily by rubbing the fur with the palms of the forepaws; water is pressed from the fur and removed with the tongue (Kenyon 1969). This behavior would allow for the ingestion of oil. It is interesting to note that an otter's pelage cleaned of oil using detergents may take as long as 8 days to recover its water repellency (Kooyman and Costa 1978).

Conflicting reports exist concerning the ability of sea otters to detect and escape from an oil spill. Williams (1978) observed that the two otters he was studying did not avoid oil while Barabash-Nikiforov et al. (1947) reported that Japanese poachers used petroleum to repel otters from shore rocks into the sea.

The behavior of sea otters contaminated with oil appears to vary depending on the availability of a haul out area. Williams (1978) observed that otters spent 75 percent of their time grooming underwater when oil was on the surface. There was no available haulout. This may exemplify the case of sea otters oiled far offshore. In another study oiled otters began vocalizing and hauled out (Kenyon 1972a). Vocalizing and hauling are the reactions to stress from cold temperatures (Stullken and Kirkpatrick 1955).

It appears that even small amounts of oil are sufficient to degrade the insulating quality of the fur. Kenyon (1972a) described how a thin iridescent film of oil was sufficient to cause death by exposure. The major causes of death from oiling appear to be hypothermia or pneumonia, depending on the amount of fur that is contaminated (Kooyman and Costa 1978).

If the area of a spill is adjacent to unaffected areas with high densities of sea otters, the lost animals could be quickly replaced through immigration. However, expanding colonies such as exist in lower Cook Inlet may not have such reservoirs of surviving animals. For example the Kamishak Bay population is surrounded by sparsely populated or vacant habitat. Immigrants would have to come from the Kenai Peninsula or the south side of the Alaska Peninsula but since vacant habitat remains in these areas the rate of immigration to Kamishak Bay would be slow.

As sea otters continue to repopulate their former habitat their ability to recover from oil spills will improve. At the present time a single major oil spill has the potential for setting back the process of repopulation of former habitat for 10 or 20 years.

Food is believed to be the primary factor determining carrying capacity of sea otter habitat. A reduction in densities of sea otter food items could reduce sea otter numbers in areas.

The importance of food in determining the carrying capacity of many species is not clear, however the available evidence indicates that it is the primary factor determining the capacity of habitat to support sea otters. Therefore, a reduction in densities of sea otter food species in an area where sea otters are near maximum levels is likely to reduce the number of sea otters in that area. Most sea otter prey are relatively sedentary. A localized reduction in food is likely to result in a localized reduction in sea otter densities. Reductions in prey in areas where sea otter densities are well below maximum could significantly alter the rates and patterns of repopulation of former sea otter habitat.

The time between oil contamination and death has been recorded to be only several hours (Kenyon 1972a) in one case and less than 24 hours in another (Williams 1978). Death due to malnutrition and the stress of confinement have varied from a few hours to 11 days (Stullken and Kirkpatrick 1955). The health of the otter and environmental condition at the time of stress appear to be important variables. The short time that can take place between the inducement of stress and death could reduce the chances of a successful program for rehabilitating oiled otters.

Sea otters need to eat approximately 25 percent of their body weight per day and cannot undergo long periods of fasting (Stullken and Kirkpatrick 1955). Insufficient food combined with other stresses has been shown to be sufficient to cause gastro-enteritis and possibly death (Stullken and Kirkpatrick 1955). Should an oil spill occur and otters are able to escape direct oiling, the possible disruption of their feeding habits, cold stress due to even a slight oiling, and the stress due to exposure during periods of inclement weather all could provide an accumulated stress which may prove fatal. This would be magnified during times of prolonged foul weather when otters are already experiencing sublethal environmental stress (Stullken and Kirkpatrick 1955).

An acute oil spill entering sea otter habitat may quickly kill most sea otters in the immediate area. If this occurs in a female area a high proportion of those killed will be reproductively active females. The reproductive strategy of the sea otter is not well adapted to cope with catastrophic events which eliminate adult females. Recovery will be slower than in a species with a high rate of productivity.

In summary sea otters are highly vulnerable to both direct oiling and indirect effects of oil through the food chain. Both mechanisms are likely to produce very site-specific impacts. The significance an oil spill to the sea otter population as a whole will vary according to the specific area affected. Because sea otter populations in lower Cook Inlet are still expanding into vacant habitat they are more vulnerable to oil spills than if all former habitat was fully repopulated. As the existing populations grow the importance of specific areas of habitat will change.

Fur Seals (*Callorhinus ursinus*)

Fur seals are similar to sea otters since their dense underfur acts as an insulator; in addition fur seals also have a subcutaneous fat layer (Kenyon 1972a).

Tests by Kooyman et al. (1976) have shown that oiling of 30 percent of the pelt surface area resulted in a 1.5 fold increase in the metabolic rate, an effect that lasted for at least two weeks. Seals were also reluctant to enter the water after being oiled, a result probably due to the increased heat loss through the fur. If oiled seals hauled out for longer periods of time, then feeding could be disrupted which would add to the metabolic drain which was already occuring from the loss of insulation.

Kenyon (1972a) reported that fur seals entering busy shipping lanes may be contanimated with oil. He concluded that oiled seals do not return to their breeding grounds in the Pribilof Islands since no contaminated seals were observed there among the hundreds of thousands harvested.

Phocid Seals and Sea Lions

External oil contamination has very little effect on phocid seals and sea lions since they rely on a subcutaneous fat layer for insulation (Kooyman et al. 1976).

The ingestion of crude oil has been shown to cause kidney damage in ringed seals (*Phoca hispida*) (Smith and Geraci 1975). It was hypothesized that the route of entry included accidental swallowing and absorption through the skin and mucous membranes. Respiratory absorption may be an important pathway, especially with fresh crude oil, which still contains the more volatile fractions. Eye damage, including lacrimation, conjunctivitis and corneal erosion also occurred, with the severity of damage related to exposure time (Smith and Geraci 1975).

It has been hypothesized (Smith and Geraci 1975) that oiling of nursing pups may prove to be detrimental due to ingestion or absorption of oil. There is little data on this subject. LeBoeuf (1971) found no effects of oiling on elephant seal (*Mirouinga angustirostris*) pups, but these young had already been weaned. Brownell and LeBoeuf (1971) also concluded that oiling did not contribute to California sea lion (*Zalophus californianus*) pup mortality. It is interesting to note that the oil in question was weathered before contacting the pups and probably had lost the more toxic, aromatic fractions. Certainly, large amounts of oil on steller sea lion rookeries during the period when pups are unable to swim would cause high mortality.

Davis and Anderson (1976) studied the effects of oil on grey seal (*Halichoerus grypus*) pups. They found that oiled pups had significantly lower weights than unoiled pups, but attributed this to either interference of mother-pup relationship due to masking of the identifying smell or due to the greater human disturbance of oiled pups from veterinary inspections, cleaning operations and visiting observers.

There is little data on the ability of seals and sea lions to avoid oil slicks. Smith and Geraci (1975) found that ringed seals did not try to avoid oil under experimental conditions, but cite an obscure reference to seals avoiding oil in the wild (Mansfield 1970 in Smith and Geraci 1975).

Sea lions are known to frequently pick up foreign objects in their mouths, a behavior which makes them susceptable to ingesting tar balls. Sea lions have been observed with tar balls lodged in their throats and others with petroleum-like substances around the lips, jaw or neck. Petroleum-like substances have also been found in their feces.

The behavior of individuals exposed to crude oil include squinting, arching the back out of the water and submerging for long durations (Smith and Geraci 1975). Other reports of aberrant behavior include Pearce (1970 in Nelson-Smith 1973) who stated "after the Arrow Spill in Nova Scotia, young grey seals were found blundering about in the woods 1/2 mile from shore unable to find their way because of oil around eyes and nostrils."

Steller sea lions are probably most vulnerable to acute oil spills during mid-May through mid-July, the period of time they are on the pupping and breeding rookeries. The only major rookery in the lower Cook Inlet area is Sugarloaf Island in the Barren Islands. The coastline of Sugarloaf Island is dominated by large boulders, rock outcrops and cliffs intersperced with pocket beaches of coarse sand or gravel. If a major oil spill occurred here during the pupping period, the potential would exist for substantial pup mortality to occur even though Hayes et al. (1976) would probably place this area in a low risk classification.

Cetaceans

There is little or no data on the direct effects of oil on cetaceans (Fraker et al. 1978). Orr (1969) found no evidence that oil from the Santa Barbara spill was a mortality factor in the death of beached whales in the vicinity of the spill.

The potential exists for oil to be absorped into the respiratory tract by whales surfacing into an oil spill. There are relatively small amounts of hydrocarbons present under a spill on a calm surface (McAuliffe 1977) so it is possible that whales would not detect a spill until they surfaced.

THE EFFECTS OF CHRONIC OIL POLLUTION - A REVIEW

Chronic oil pollution is the release of petroleum hydrocarbons at a low but persistant rate. Many researchers believe that chronic pollution may ultimately prove to be the most damaging form of oil pollution (Evans and Rice 1974, Michael 1976, Boesch 1973, St. Amant 1971).

Sources of chronic oil pollution include formation waters, deck drains, fuel leaks, leaky pipeline valves, ship's bilges and small spills at tanker terminals (ADF&G 1978a).

Direct Ingestion of Oil

There is little data on marine mammals ingesting crude oil. The noxious odor and taste would probably be an adequate deterrent during acute oil spills. Direct accumulation of hydrocarbons could occurr if marine mammals ignore or are unable to detect low levels of pollution.

The behavior of some species could increase the amount of oil ingested. Sea otters are constantly grooming their fur and would be susceptable to sublethal doses of oil. Williams (1978) found that sea otters spent considerable time grooming after being oiled and one could hypothesize that otters inhabiting contaminated waters would increase their grooming activities in order to maintain the insulating quality of the fur and in turn ingest more oil.

Baleen whales could pick up oil particles or tar balls while feeding. Gray whales have been observed exhibiting feeding type behavior in an area where tar balls were coming ashore daily. The current patterns appeared to concentrate food items in the area and in turn could accumulate floating debris such as tar balls which would increase the chance of whales ingesting them.

Mortality of Prey Species

Acute and chronic pollution could lead to direct mortality of important prey species such as crabs (*Chionoecetes* sp.) (Karinen and Rice 1974), shrimp (*Pandalus* spp.), (Rice et al. 1976), sea urchins (Allen 1971), and several species of fishes (Rice 1973, Morrow 1974, Rice et al. 1976, Struhsaker 1977). Plankton are the only major category of prey in which there is a lack of evidence for major impacts (Michael 1977).

Oil Uptake through the Food Web

Studies have been inconclusive concerning the degree which hydorcarbons accumulate in the food chain (National Academy of Science 1975, Boesch 1973). Apparently most species tend to depurate most of the hydrocarbons they accumulate when placed in clean water (Fossato and Cazonier 1976, Lee 1977), although the more toxic aromatic hydrocarbons have been known to be retained in shellfish for several months (Blumer et al. 1970). Studies have shown that low concentrations can disrupt physiological and sensory mechanisms in crustacea, molluscs and fish (Karinen and Rice 1974), which could cause a significant reduction in their population levels. A comprehensive summary of the various sublethal effects of oil pollution on invertebrates and fish can be found in ADF&G (1978a).

The aberrant behavior and unnatural movements of contaminated prey can make them more vulnerable to predation (Hess 1978); marine mammals feeding in contaminated water could become selective feeders on oil laden prey due to their ease of capture and thus be exposed to greater amounts of hydrocarbons.

Another result of chronic and acute oil pollution would be the "tainting" of prey species (Krishnaswami and Kupchanko 1969, Nelson-Smith 1971, Knieper and Culley 1975, Lee 1977). There is the possibility that "tainted" prey species may be less desirable food items which could result in a change in diet to other untainted species or a reduction in feeding. This phenomena may not always occur since only a small fraction of petroleum has a pronounced odor or taste (National Academy of Sciences 1975).

THE EFFECTS OF DISTURBANCES ON MARINE MAMMALS - A REVIEW

Disturbance can be defined as the physiological and behavioral stress animals experience as a result of human-related physical intrusion into their environment (Trasky et al. 1977). The activities associated with oil and gas exploration and development have the potential for causing disturbances. The primary sources are helicopters, fixed-winged aircraft, boats, human presence, onshore and offshore support facilities and seisimic exploration.

Aircraft

Aircraft flights during oil exploration have been projected to include between 150 and 225 helicopter trips and at least 45 fixed-wing trips per month from offshore rigs to Homer or Kenai. Air traffic is expected to further increase during the development phase.

Different types of aircraft appear to have substantially different effects on marine mammals. Helicopters have a more sever effect than fixed-wing aircraft. Larger helicopters such as the Bell 205 have a more pronounced effect than smaller helicopters such as the Bell 206.

The only intensive study of aircraft disturbance on marine mammals was done by Johnson (1977), who observed harbor seals on Tugidak Island. He found that aircraft flying at altitudes of less than 123 meters and particularly less than 30 meters resulted in most seals in a herd entering the water. Flights at higher altitudes had varying reactions depending on the weather and past disturbances in the area. Both calm days and frequent disturbances tended to increase the seal's wariness. Helicopters tended to be the most disturbing type of aircraft.

Due to the aircraft's mobility the entire island's population was frequently disturbed and chased into the water. Aircraft have the capability of being the most intensive and extensive of all disturbing factors.

A severe disturbance usually resulted in all seals entering the water and not reusing the haulout site for at least 2 hours; seals appeared to cruise along the beach in search of other areas where seals were hauled out (Johnson 1977). Aircraft flights over seal herds in conjunction with an oil spill could be detrimental by forcing the animals into the water and increasing their contact with oil.

Aircraft disturbance also resulted in permanent separation of mother and pup in many instances, especially pups born within two hours before or one half hour after a major disturbance. Aircraft disturbance alone accounted for more than 10 percent mortality of pups born on Tugidak Island (Johnson 1977).

Sea lion reaction to aircraft is varied and depends upon multiple factors. On haulout areas when sea lions are not breeding and pupping, approaching aircraft will most generally cause some disturbance, frightening at least some animals into the water. On some occasions on haulouts, approaching aircraft can cause complete panic and stampede all sea lions to the water. The variability in reaction on haulouts appears to depend on environmental conditions (weather, tide, etc.) as well as the type, speed and altitude of the approaching aircraft. When sea lions are on breeding rookeries during the breeding and pupping season their reaction to aircraft is altered and appears to depend more upon the sex, age and reproductive status of the individual. Immatures and pregnant females may enter the water when aircraft approach, while territorial males and females with small pups generally remain hauled out and vocalize.

Fraker et al. (1978) cites two observations of belukha whale reactions to aircraft. On one occasion whales appeared to look skyward at a single engine aircraft flying at an altitude of 300 meters and in another instance a group of whales retreated into deep water after a twin engine aircraft flew over at 300 meters. The water was clear and it was hypothesized that whales in clear water may be more easily disturbed by aircraft.

Although no quantifiable data are available, other whales such as humpbacks, grays and fins appear to alter the behavior to avoid approaching aircraft. Often when repeatedly approached by low flying aircraft all of these species appear to dive and remain submerged for longer periods.

Boats

Boats can also be a cause of disturbance. Loughlin (1974) believed that the absence of seals in two bays in California was due to extensive commercial and sport boat traffic. A sport boat launching ramp in another area was believed to be restricting the formation of a large permanent population or pupping colony in that area (Loughlin 1974).

Boats have been observed to disturb belukha whales. Fraker (1978) observed whales swimming rapidly away from a barge under tow; whales reacted within 2,400 meters of the barge. The scattering effect was still observable for 3 hours afterward although the distribution returned to near normal after 30 hours. Heavy barge traffic could block or, at least, impede whale movement (Fraker et al. 1978).

Studies in Glacier Bay have shown that humpback whales, killer whales and Dall porpoises are disturbed by boats. It appears that the sounds generated by boats can cause these animals to abandon an area when feeding, resting or traveling (Jurasz pers. comm. in MCHM 1979). The apparent echo location abilities of sea lions (Poulter 1963) may also make them more sensitive to boat traffic.

Human

Disturbance due to the presence of humans will most likely have the greatest impact on those marine mammals using the terrestrial environment. These would include seals and sea lions, and to a lesser degree sea otters.

It has been observed that human harassment was an important factor in the abandonment of hauling areas for California sea lions, Guadalupe fur seals (USDI 1976) and Steller sea lions (Kenyon 1962). Construction appeared to cause harbor seals (Calambokidis et al. 1978) and Steller sea lions (Pike and Maxwell 1958) to abandon favored hauling grounds. California sea lions (USDI 1976) and Hawaiian Monk seals (*Monachus schauinslandi*) (Kenyon 1972b) have been observed utilizing areas whose main characteristic was its inaccessibility to humans.

Johnson (1977) considered disturbances by hikers and all-terrain vehicles as detrimental as aircraft to harbor seals and therefore an important potential mortality factor. Kenyon (1972b) believed human disturbance increased juvenile mortality of the Hawaiian Monk seal. There is some evidence from fur seal studies that human disturbance causes weight loss and higher mortality among pups (USDI 1976).

Seismic activities during exploration may also be a disturbing factor. Porpoises and possibly belukha whales are attracted to side scan sonar used in seismic work (Ken Holden pers. comm. in Hamilton 1979). Belukha were observed to give artificial islands a wide berth due to the sound generated on them (Fraker et al. 1978).

Studies on California sea lions (Poulter 1966) showed the real possibility of an active sonar mechanism in this species. The sensitivity of marine mammals to underwater sounds could be an area of concern.

It should be noted that man-made structures were used for haulout areas by harbor seals in Washington (Calombokidis et al. 1978). Log booms and oyster rafts were used, although oyster rafts were preferred, probably due to the less frequent human visits to these structures. Seals also tended to haulout nocturnally on man made structures, thus lessening human encounters and disturbances.

Sea otters are relatively tolerant of human disturbance as exhibited by groups of sea otters living near dense human populations in California. There is evidence that some sea otters, particularly females with pups, will avoid areas of regular disturbance, but again no quantitative data are available.

DRILL CUTTING AND DRILLING MUDS

Drilling muds are a complex mixture of organic and inorganic materials whose main function is to remove cuttings from the bore hole, cool and lubricate the drill bit and hold back formation pressures (Trasky et al. 1977). Approximately 100 cubic meters of drilling mud and up to 450 cubic meters of drill cuttings will be discharged into the marine environment for every well completed (Trasky et al. 1977). Drill cuttings from one well could cover up to 23,000 square meters of bottom (Trasky et al. 1977), although the strong currents in Cook Inlet will probably prevent accumulation of a visible cutting pile (Dames and Moore 1978). It has been estimated that 32 exploratory wells will be drilled in the study area between 1978 and 1985 (Warren 1978). Although the bulk of the drilling mud is composed of nontoxic substances such as bentonitic clay, additives such as oil, surfactants, caustic soda and bactericides are used to improve the properties of the mud (Robichaux 1975).

Drill cuttings and muds will have little direct impact on marine mammals due to their localized nature and relative nontoxicity. The possibility exists for contamination of prey species from the mud addatives although the relative significance of this pollutant source is unknown.

FORMATION WATERS

Formation waters are waters associated with oil and gas deposits. The water is produced along with oil and gas and may exceed the volume of petroleum produced (Brooks et al. 1977). The water is characterized by higher salinity and temperature and lower oxygen content than seawater (Levorsen 1967). Formation waters, when discharged, can contain up to 50 ppm of hydrocarbons and varying amounts of heavy metals and hydrogen sulfide (Trasky et al. 1977).

The impact of formation waters appears to be confined to the area near the drilling platform, especially at drill sites in deep water (Mackin 1973), such as lower Cook Inlet. The effect of formation waters on marine mammals in lower Cook Inlet is unknown at present.

ENTRAINMENT

The cooling system of drilling platforms and vessels use up to 13,600,000 liters of seawater each day (EPA 1977). The water is heated from 17° to 22°C above ambient water temperature before being returned to the sea (Trasky et al. 1977). The cooling systems have the potential for the entrainment of crab, shrimp and fish larvae and plankton, resulting in 100 percent mortality due to the increased temperature (Trasky et al. 1977). Potentially the most significant impact associated with entrainment would be the loss of prey.

PIPELINE LAYING OPERATIONS

It has been estimated that up to 241 kilometers of pipe will be buried under the sea floor which would result in temporary resuspension of 0.34 to 0.92 million cubic meters of sediment (USDI 1976). The resettling of the sediments could cause smothering of benthic organisms. Pipe laying operations could be a disturbing factor and temporary abandonment of the waters in the vicinity of the operation is possible.

ACKNOWLEDGMENTS

Several people contributed substantially to the preparation of this report and deserve special recognition. James A. Curatolo participated in all phases of the early drafts of this report and was responsible for the literature research and preparation of the review of effects. Karl Schneider prepared the section on sea otters, Ken Pitcher prepared the section on harbor seals and Nancy Murray prepared the initial draft of the section on belukha's.

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